Transport Canada Transports Canada

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Transportation Development Centre
Policy and
Coordination Group

TDC PROJECT DIRECTORY

Canada

TDC Project Directory

Transportation Development Centre
Policy and Coordination Group
Transport Canada

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Minister
Transport Canada

Ministre
Transports Canada

Canadians count on the safety and efficiency of transportation. Our national transportation systems continue to provide us with easy access and support for sustained economic development.

Transport Canada, in cooperation with the transportation industry, strives to ensure that all modes are safe, productive and economical. This is an on-going challenge that calls for innovative application of the latest technological advances.

The Transportation Development Centre (TDC) plays an integral role in meeting this challenge. Through a full, responsive program of transportation research and development, TDC sponsors projects to improve our air, marine and surface systems. It also helps ensure transportation is accessible for travellers with disabilities.

The Centre undertakes its research program in cooperation with other components of Transport Canada, other federal departments, the provinces and the private sector. Working together, TDC and its R&D partners ensure that our needs and expectations for safe, reliable and efficient transportation are met. This 10th edition of the *Project Directory* documents the success of these collaborations.

We look forward to continued progress and innovation.

The Honourable Benoit Bouchard, PC, MP
Minister of Transport

PREFACE

This is the tenth in a series of project directories describing the research and development activities of Transport Canada's Transportation Development Centre (TDC). The previous edition was published in January 1987. This edition covers selected projects and describes their activity until June 1988.

The directory is divided into four sections: rail, surface, air, and marine. These are the principal areas of TDC's research and development program in transportation technologies.

Each project description briefly states the rationale, objectives, and method of the project, and gives an account of completed work. Also given are the name of the performing organization, the titles of reports, the work schedule, project and file numbers, funding sources, and the name of the project officer.

A list of recent reports published is given at the end of the directory.

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INTRODUCING THE TRANSPORTATION DEVELOPMENT CENTRE

The Transportation Development Centre (TDC), formed in 1970, is Transport Canada's centralized research and development (R&D) organization. TDC formulates, initiates, manages, or reports on an average of 300 R&D projects a year. These projects are contracted to a variety of organizations, most of them in the private sector, and cover all transportation modes, systems, and technologies. TDC serves as Transport Canada's centre of expertise on transportation technology and innovation.

In February 1988 Transport Canada announced a policy of sustained commitment to the R&D required to meet the department's and the transportation sector's needs for technological innovation through sustained and stable funding for a Core R&D Program. The administration of the program has been placed in the hands of the Assistant Deputy Minister, Policy and Coordination, aided by a new top-level R&D Council that will provide advice on objectives and priorities.

The chairman of the R&D Council is the Director General, Research and Development, Policy and Coordination Group. There are twelve members representing Transport Canada's modal groups and TDC. Among other things, the new Council enables long-range priorities to be established and research to be carried out on a sustained basis. R&D can now go further into the future and not be subject to the ups and downs of an annual budget.

TDC reports to the Director General, Research and Development and works in accordance with directives and guidelines of the Core R&D Program. These directives establish R&D priorities and requirements in support of Transport Canada's activities and of federal science and technology policy. They also reflect requirements as expressed through transportation R&D advisory boards.

Implicit in these responsibilities is the need to maintain close working relationships with the transportation technology community, to allow for the most efficient use of R&D resources. The Core R&D Program covers three types of R&D:

- **Exploratory R&D** aims to produce knowledge through systematic assessment of new developments. It does this by identifying technological innovations with the potential to improve elements of transportation systems. Methods include: technology scanning, forecasting, and assessment; experimental testing; and, consultative workshops and symposia. Investigations frequently are high-risk, require long-term monitoring, and involve a wide range of users, R&D performing organizations, and interest groups.

- **Long-Term Applications R&D** consists of programs undertaken in support of the objectives of other components of Transport Canada. These programs generally last several years, but can include any application R&D program. Some of these programs also support the department's capital investment plans.

- **Sector-Directed R&D** supports innovations in the transportation sector at large that further Transport Canada's objectives and priorities. The R&D programs are determined by policy directives for safety, productivity, regional development, and environmental protection. Long-term safety and productivity issues relating to air, marine, and rail modes are some of the concerns sector-directed R&D may address. These kinds of programs involve cooperation with the provinces, industry, and other federal departments and agencies.

The research is carried out by TDC in close cooperation with its colleagues in the operating groups of Transport Canada: Airports Authority, Aviation, Marine, and Surface. They contribute directly to this effort by helping to define the R&D objectives and review the technical work, and participating on project steering committees, which provide advice and guidance to the TDC project officer. While it is not practical to outline the nature of the support on each activity described in the Project Directory, this valuable assistance is acknowledged as a key element in the success of the Core R&D Program.

Funding

The centre's research projects have been funded largely on a cost-shared basis with other Transport Canada components, other federal departments, industry, or the provinces. Major contributors to R&D projects described in this directory are the Department of Energy, Mines and Resources (EMR) through its Energy R&D Program; the Cabinet Committee for Economic and Regional Development through its Transportation for Disabled Persons Program (TDPP); the federal government and the province of Quebec through an Economic and Regional Development Agreement (ERDA) sub-agreement on transportation development; other components of Transport Canada, including the Canadian Coast Guard (CCG) and the Surface, Aviation, and Airports Authority groups.

TDC Organization

TDC is organized into five operating divisions: Current Technology, Advanced Technology, Technology Applications, Transportation Systems Technology, and Research Analysis and Special Programs. Current Technology projects are aimed at improving existing transportation technology.

These projects involve developing prototypes and conducting test programs. Follow-up work frequently involves in-service evaluation by transport operators.

Advanced Technology projects investigate new concepts and innovative technical solutions that promise to overcome shortfalls in transportation systems using conventional technology. Developments resulting from these projects are supported by quantitative assessments of the economics and user-acceptability of the technology.

Technology Applications projects involve the systems analysis studies needed to establish a base for assessment and comparison. Demonstration projects introduce new methods, equipment, and systems on an experimental basis.

Transportation Systems Technology projects are aimed at developing major new Canadian transportation systems. This division emphasizes marine transportation in the Arctic and off the East Coast, and off-road transportation in remote regions. The ergonomic design of transportation equipment and systems is considered.

Research Analysis and Special Programs involve operational planning for TDC as well as program evaluation and technology forecasting. The emphasis here is on urban transportation and transportation for elderly and disabled persons. This was the division that responded to the government's 1984 R&D policy on transportation of disabled persons, which highlighted the urgent need to improve the accessibility of transportation services for elderly and disabled travellers. The projects relating directly to this subject are grouped under a separate heading in the surface and air sections of this directory.

Judith Nogrady Library

TDC also has a comprehensive transportation technology library. Renamed in October 1988 in honour of its founding librarian, the library has approximately 15 000 books and reports, 5 000 documents on microfiche, an audio-visual collection, and Statistics Canada publications. As well, the library subscribes to more than 500 periodicals and has on-line access to three data-base systems: DIALOG, ORBIT, and CAN/OLE. Supplementing these systems, the library has on-line access to the holdings of about 500 Canadian libraries through the University of Toronto Library Automation System (UTLAS).

Publications

Each TDC project is documented by a technical report. A list of recent publications, along with ordering information, appears on page 153.

Unsolicited Proposals

TDC also considers unsolicited proposals for R&D projects. These submissions are received through the Unsolicited Proposals Program administered by Supply and Services Canada. For more information, contact: Director, Science Programs Branch, Science and Professional Services Directorate, Supply and Services Canada, Ottawa, Ontario K1A 0S5. Telephone: (819) 956-1784.

RAIL
TECHNOLOGY

RAIL TECHNOLOGY

A safe and efficient rail transportation system is vital to the country. For Canadian industry, the cost of delivering goods, especially bulk commodities, by rail determines in part industry's competitiveness in both domestic and foreign markets. For the Canadian public, safe and reliable rail service is essential.

TDC funds a number of research and development projects in rail transportation. These projects are undertaken in conjunction with railways, railway equipment manufacturers, consulting companies, and research organizations.

Safety

TDC supports projects aimed at improving the overall safety of the rail system as well as supporting the department's regulatory functions. Projects aimed at future safety improvements include research into detecting wheel cracks by acoustic methods and using light-emitting diodes for level-crossing warning lamps. Projects in support of regulatory functions include the development of a dangerous goods accident model and research into the behaviour of tank cars during a fire.

In August 1987 TDC, in cooperation with the Natural Sciences and Engineering Research Council and the University of New Brunswick, sponsored an international symposium on major hazards in the transport and storage of pressurized liquified gases. The symposium was held at the University of New Brunswick in Fredericton, and was attended by representatives from Canada, the United States, the United Kingdom, West Germany, Portugal, Holland, and Venezuela. Participants discussed the latest developments in risk assessment, prediction experiments, and physical modelling. One result of the symposium was support for a formal agreement to be signed by Canada, the United Kingdom, and West Germany to continue research in the field.

Advanced Train Control

Increased safety, reliability, and productivity of railway operations can be realized through the development and use of improved signalling, communications, and control equipment. For several years TDC has supported a number of projects to develop advanced train control systems (ATCS) based on new communications and computer technology.

Motive Power

TDC is helping to develop technology to meet the future requirements of Canadian railways for productive and fuel-efficient motive power. One project involves completion of a single-cylinder engine test facility for research into fuels and lubricants that are likely to be available in the future for railway use. Another project involves research into a dual-fuel (diesel and natural gas) engine. The dual-fuel project is part of a larger program that will culminate in the demonstration of a dual-fuel, medium-speed engine in a railway locomotive.

Track and Infrastructure

In cooperation with Canadian railways, TDC is supporting research to improve railway track structure design and to develop better materials and maintenance practices. The goals of this research are to improve train performance and to extend track life. The projects are usually long term and involve laboratory work and field tests.

Wheel/Rail Systems

Knowledge of the performance of the steel-wheel-on-steel-rail system is key to identifying technological innovations in the rail mode. TDC is supporting research into the fundamental interaction of steel wheels and steel rails, with the goal of improving performance. The wear and fatigue of materials and the effects of lubrication on track design are being studied. In one project, a wheel/rail system test facility is being completed at the National Research Council. This new facility will encourage research into both the railway wheelset as a sub-system comprising bearings, breaks, wheels, and axle, and into the wheelset's interaction with the rail.

Another project, aimed at developing a fabricated, high-speed rail truck, is being conducted in cooperation with the province of Quebec under an Economic and Regional Development Agreement.

Railway Wheel Crack Detection System

Defects in railway truck wheels are currently detected by time-consuming and costly visual inspection. To ensure operational safety, wheels with less than 50 percent wear are frequently removed for suspected defects. Several in-track automatic systems using acoustic and ultrasonic technologies have been tested, but none is in general use.

The objective of this project is to determine whether acoustic methods using intensity analysis meet railway performance requirements for wheel crack detection. Specifically, researchers are trying to develop a cost-effective wheel fault detection system that is capable of identifying damaged wheels at train speeds of up to 25 km/h.

The work is being undertaken with the cooperation of CN Rail and CP Rail. Field tests will be carried out at CN wheel shop facilities in Montreal.

The results of the initial work will help determine the technical feasibility of the approach. Consideration may then be given to extending the work to include design, installation, and testing of an automated field system suitable for the Canadian environment.

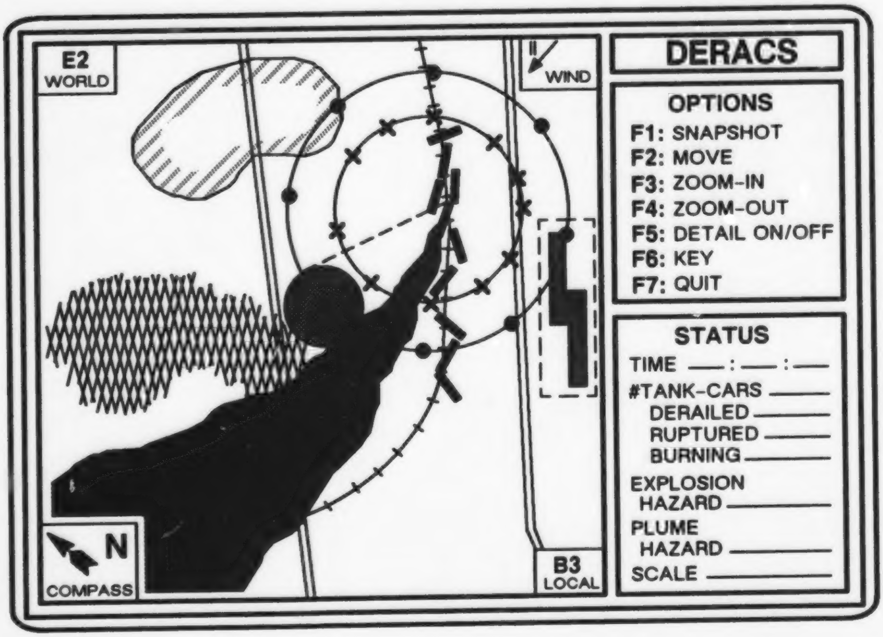
Contractor: SNC Inc., Montreal, Quebec

Report: None to date

Schedule: July 1987 - July 1989

Funding:	Supply and Services Canada	$80 000
	TDC	$65 000
		$145 000

Project Number: 6941
File Number: D 1465-516
Project Officer: Neil R. Gore


E2
WORLD
WIND
DERACS
OPTIONS
F1: SNAPSHOT
F2: MOVE
F3: ZOOM-IN
F4: ZOOM-OUT
F5: DETAIL ON/OFF
F6: KEY
F7: QUIT
STATUS
TIME ___:___:___
#TANK-CARS
DERAILED
RUPTURED
BURNING
EXPLOSION HAZARD
PLUME HAZARD
SCALE
N
COMPASS
B3
LOCAL

DERACS accident view at local level. The model simulates derailment accidents involving up to 40 cars, eight of which can be tank cars.

Development of a Dangerous Goods Accident Model

The transportation of dangerous goods over Canadian highways and railways is regulated by the federal government. The regulators need reliable risk assessment tools in order to protect public safety while not unduly constraining commercial enterprise.

In this project researchers developed a comprehensive computer simulation of an accident involving the transportation of dangerous goods. Both rail and highway transportation were considered but the emphasis was on rail. The simulation models an accident and its consequences, including derailment, impact-induced ruptures of containers, spills and releases of dangerous substances, fires, and explosions.

The researchers used several existing models, including a plume dispersion model, a derailment model, and a spill leak model. A tank thermal model developed in an earlier project was modified to handle up to eight burning tank cars simultaneously.

The result of this work is a computer program, DERACS, which operates on an IBM AT or compatible computer. The program will help planners and risk managers to estimate typical outcomes of derailment accidents and to consider safety alternatives. To develop DERACS into a comprehensive software package for simulating both rail and highway accidents, a number of enhancements have been recommended. These include adding more commodities, upgrading certain models used in the prototype, and developing a program for application on a powerful computer.

When fully calibrated, the program will be turned over to Transport Canada's Dangerous Goods Directorate for their use.

Contractor: W.R. Davis Engineering Ltd., Ottawa, Ontario

Report: *(Draft)* Development of a derailment accident computer simulation model, W.R. Davis Engineering Ltd., 1988

Schedule: March 1987 - May 1988

Funding:	Dangerous Goods Directorate	$79 100
	TDC	$32 742
		$111 842

Project Number: 6835
File Number: D 1465-503
Project Officer: Doug W. Dibble

Tank Explosion Suppression

Using rail and road tank cars to transport liquified petroleum gas is hazardous. As more tank cars are used for this purpose, ways must be found to reduce the risk of explosion after collision or derailment. An explosion occurs when a fire around a car raises the wall temperature of the tank to the point of rupture.

A major facility that allows for data collection and visual observation of the liquid and vapour phases created by simulated fire conditions exists at the Fire Science Centre of the University of New Brunswick (UNB); TDC has supported research at the Centre for several years. Researchers, however, have yet to produce a design for a tank car protection system that fully meets the operational requirements of carriers.

The objective of this project was to perfect a new design for a protection system. The design consisted of an internal shell separated from the outer tank wall by an annular space. When the tank is heated, a pressure differential forces the liquefied petroleum gas and gas vapour to flow from the inner shell through the annular space to the relief valve; in passing through the annular space, the gas helps to cool the tank wall.

The project plan included preliminary mechanical and thermal design feasibility studies. The mechanical feasibility study covered structural design, operations, and fabrication. Results indicated that from a structural and operations perspective the design was workable. The internal shell would significantly affect only infrequent operations such as detailed inspections.

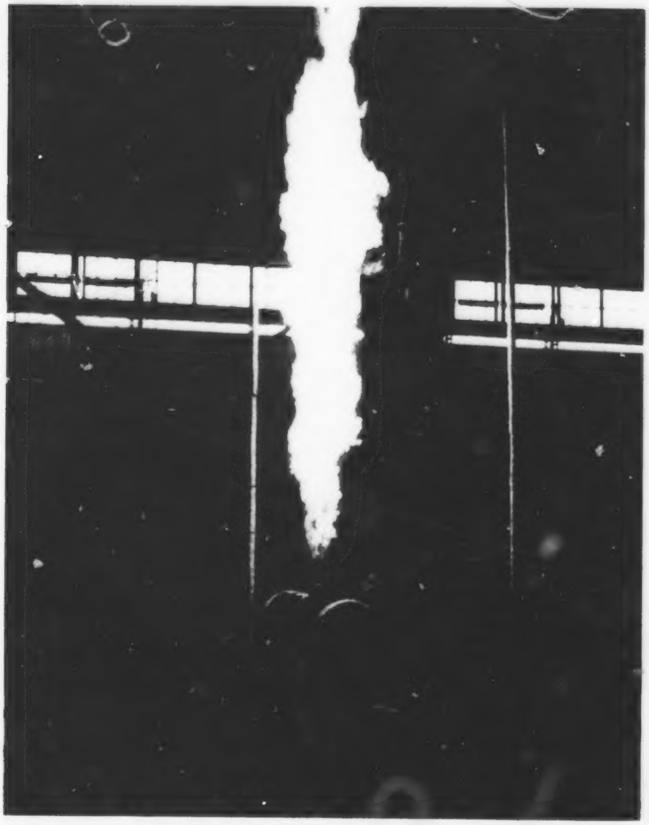
A preliminary thermal feasibility study was conducted using UNB test facilities and a previously developed tank thermal model. The researchers concluded that there were too many technical uncertainties and that a more comprehensive thermal design study should not be pursued. The annular design will not be carried further at this time.

The project did demonstrate that the tank thermal model and the UNB test facility are important cost-saving tools for assessing tank designs.

Contractor: W.R. Davis Engineering Ltd., Ottawa, Ontario

Reports: TP 7986E, An explosion suppression system for rail tank cars and other containers holding pressurized liquids – mechanical design study, W.R. Davis Engineering Ltd., 1986

TP 8781E, Tank-car internal shell explosion suppression system: preliminary thermal feasibility study, W.R. Davis Engineering Ltd., 1987

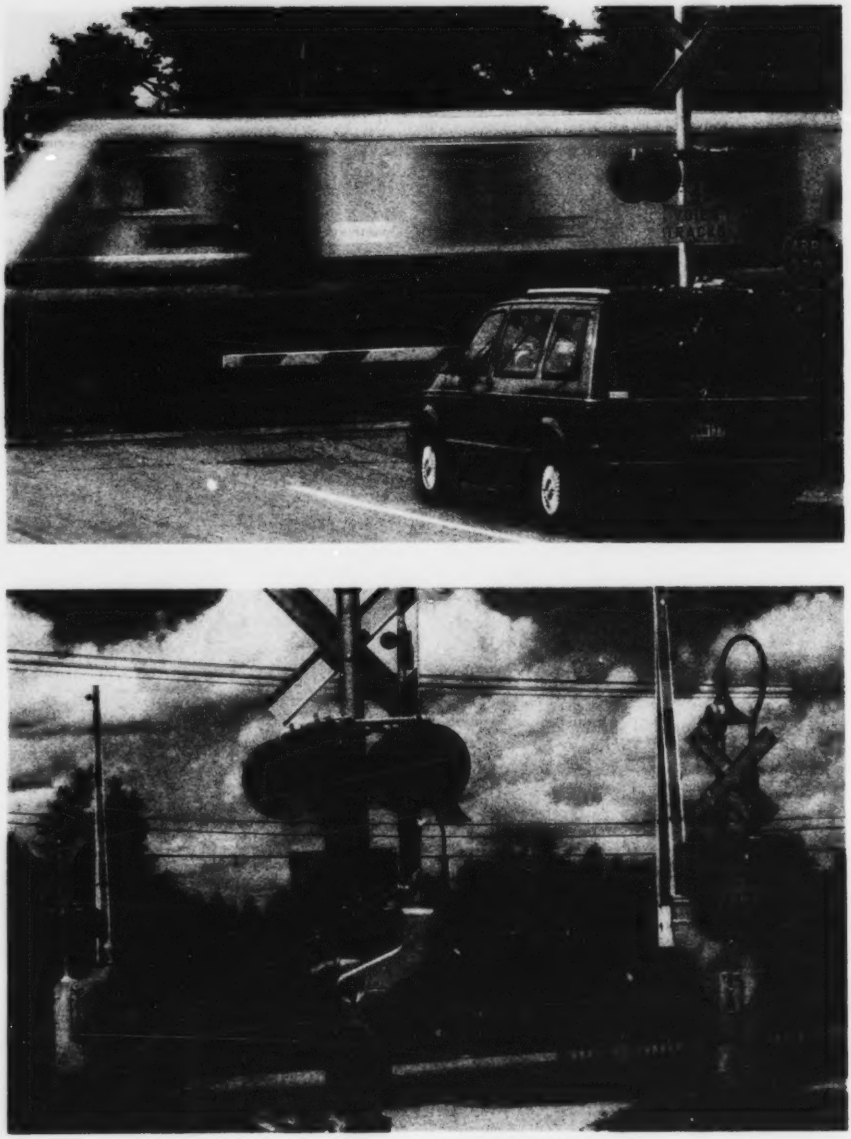


Experiment conducted to measure the thermal effects of a burning relief-valve flare during preliminary thermal feasibility study

Schedule: December 1985 - December 1987

Funding:	EMR - Energy R&D Program	$82 000
	Supply and Services Canada	$38 000
		$120 000

Project Number: 6477
File Number: D 1465-302-9
Project Officer: Doug W. Dibble



Level crossings displaying flashing lights, gates, and crossbucks
(Photos courtesy of CN Rail)

Driver Behaviour at Railway Level Crossings

Many factors contribute to the hazards of railway level crossings. These include rail/highway geometry, sight-line obstructions, inadaquate warning signs and signals, and poor highway traffic management. An unknown factor is the behaviour of motorists. Recklessness, drug and alcohol impairment, and uncertainty about how to approach and traverse railway crossings may contribute to accidents.

In this project researchers used videotape to record and analyze driver behaviour at selected level crossings, both in the absence and presence of approaching trains.

The researchers selected seven railway level crossings for study. The crossings were equipped with various warning devices, including flashing lights and gates, flashing lights only, and crossbucks only. A total of 300 hours of videotape were recorded during the summer of 1987. Speed profiles were recorded for all of the road vehicles taped.

The researchers analyzed the tapes and other information for road vehicle approach speeds and for critical incidents that increased the potential for an accident. The researchers are preparing a written report on the project and a videotape documentary. The film will be used to sensitize road, railway, and government authorities to driver behaviour that may cause accidents at level crossings and to the need for consistent rules and standards.

Contractor: Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report: *(Draft)* An analysis of video-recorded driver behaviour at seven railway level crossings: signal activations, approach speeds and critical incidents, Queen's University, Canadian Institute of Guided Ground Transport, 1987

Schedule: June 1987 - June 1988
Funding: TDC $40 000
Project Number: 6919
File Number: D 1465-496-2
Project Officer: Neil R. Gore

Light-Emitting-Diode Warning Signal

One half of all the accidents at railway level crossings occur at crossings with automatic protection; most occur in daylight. There are some 32 000 level crossings in Canada: 73 percent are equipped with standard or reflectorized crossing signs only, while 27 percent are protected with some form of warning device, ranging from wigwags to automatic flashing lights, bells, and gates. The number of accidents at level crossings could be reduced by making flashing lights more conspicuous.

The objectives of this project were to develop and build a prototype grade crossing light using light-emitting-diode (LED) technology and to assess its conspicuity in comparison with conventional, filament-type lights currently in use. Particular emphasis was placed on assessing detectability and driver reaction times for various signal modulation rates and luminance levels.

LEDs are more reliable and less costly to maintain than conventional lamps. LED technology also offers greater flexibility to implement flashing rates and patterns that are more conspicuous, particularly in daylight and against distracting visual backgrounds. However laboratory and field tests of the prototype showed that the LEDs were unable to meet the overall luminance levels required for level crossings. Several recommendations were made for technical changes to increase luminosity. TDC and CN Rail are studying the proposed changes.

Contractor: W.R. Davis Engineering Ltd., Ottawa, Ontario

Report: Non-releasable, contains proprietary commercial information

Schedule: September 1986 - March 1988

Funding:	**TDC**	**$130 000**
	Supply and Services Canada	**$43 800**
		$173 800

Project Number: 6719
File Number: D 1465-378-4
Project Officer: Wayne G. Rowan

Error-Coding Technique for Advanced Train Control Systems

The recent adoption of advanced train control systems by several rail companies in North America places heavy demands on radio channels. The mobile digital radio systems now being used by railways are derived from products developed for communications networks for automobile fleets. These systems do not have powerful error-correction capabilities because software and hardware implementation of these capabilities were perceived as complex and costly. However, new components and a better understanding of forward error correction (FEC) techniques now permit the development of advanced FEC systems. Both the Railway Association of Canada and the Association of American Railroads consider reliable and efficient digital communications channels to be important to the development of safe and economical signalling and control technology.

In this project researchers are examining digital communications systems used for rail applications and the noise characteristics of the radio channels in order to:

- assess the message error probabilities associated with the current design;
- propose an overall approach to modem error detection/correction (CODEC) systems optimized for railway environments; and,
- compare the performance of existing and proposed systems by simulating communication channel behaviour using existing protocols and the one proposed in this project.

The analytical phase of the project includes a comparative study of suitable FEC schemes based on the statistical nature of the error sequences in communications channels associated with advanced train control. In the practical phase of the project, researchers will demonstrate the CODEC system exploiting microprocessor technologies.

Contractor: Binary Communications Inc., Victoria, British Columbia

Report: None to date

Schedule: September 1987 – September 1988

Funding:	**TDC**	**$46 373**
	Supply and Services Canada	**$45 000**
		$91 373

Project Number: 6930
File Number: D 1465-514
Project Officer: Micha Avni

Railway Signal Compliance Monitoring

The most frequent cause of railway operating accidents is human error, not equipment failure. Automatic Train Control System (ATCS) technology offers a cost-effective way of automatically monitoring signal or speed compliance, alerting the engineer to a potentially dangerous situation, and even taking action to brake the train if necessary. As yet, there is no readily available way of interfacing ATCS with existing wayside signalling systems in centralized traffic control (CTC) territory where traffic density is high and the risk of collision is greatest.

In this project, the contractor has proposed a system that combines ATCS technology and current wayside signalling technologies. The system offers an immediate, cost-effective method of adding signal aspect monitoring to territory already equipped with wayside signals. Locomotives would interrogate signal locations by data radio and the information obtained, representing the signal condition, would automatically be acted on by on-board equipment if the engineman fails to respond.

Researchers are developing the software and hardware to equip two locomotives and ten wayside signal sites. In cooperation with CN Rail, the prototype equipment will be installed and tested in the field for six months.

Contractor: Signalcom Canada Corporation, Brampton, Ontario

Report: None to date

Wayside railway track signals will be interrogated by radio equipment on approaching locomotives. (Photo courtesy of CN Rail)

Schedule: December 1987 - May 1989
Funding: TDC $336 600
Project Number: 7011
File Number: D 1465-520
Project Officer: Wayne G. Rowan

Dual-Fuel Railway Locomotive: Phase 1

One of Transport Canada's objectives for the 1980s is to maintain fuel consumption for transportation constant over a ten-year period, despite increased demands for transportation services. To meet this objective, fuel savings must be realized through conservation and the use of alternative fuels. Research in both of these areas has been varied and effective. Also there has been a general move toward more fuel-efficient motive power for railways.

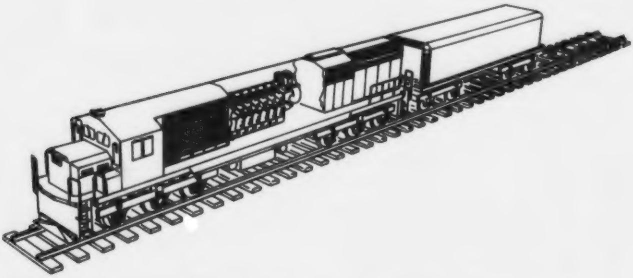
Transport Canada is collaborating with Bombardier Inc., the Canadian Gas Association, the Ontario Ministry of Energy, Gaz Métropolitain of Montreal, and Kidd Creek Mines of Ontario in a multi-phase program aimed at developing a dual-fuel locomotive capable of running on diesel fuel and natural gas. TDC's special interest in this development is to advance the current understanding of burning natural gas in a diesel engine.

In the first phase of this project researchers are developing a strategy to demonstrate a 3000-horsepower dual-fuel locomotive and associated fuel tender. The fuel to be used in the program will be natural gas with diesel fuel used as the pilot injector fuel.

Functional specifications for the locomotive and tender have been developed, conceptual drawings have been produced, and details of the demonstration phase have been worked out. The researchers have also identified modifications that would be necessary to the single-cylinder engine test facility at Bombardier Inc. to permit the use of natural gas.

Contractor: Bombardier Inc., Montreal, Quebec

Report: (*Draft*) Dual-fuel locomotive program: program definition and preliminary investigation, Bombardier Inc., 1988



Sketch of proposed Bombardier dual-fuel 3000 hp locomotive and tender

Schedule: March 1987 - April 1988
Funding: EMR - Energy R&D Program $75 000
Project Number: 6832
File Number: D 1455-150
Project Officer: Roy S. Nishizaki

Medium-Speed Diesel Combustion Research

The performance of a diesel engine is greatly dependent on the type of fuel it burns. Research on combustion in diesel engines is important because Canadian railways may be using substantial amounts of alternative or off-specification fuels in the future. Many of the tests necessary to fully understand combustion are costly and time-consuming to conduct on multi-cylinder engines. For this reason, under a previous project, Bombardier Inc. developed a single-cylinder test engine. They built two variants of the engine and associated test cells. The single-cylinder test facility offers engine manufacturers and operators flexibility in test programs that is not available elsewhere. The engines are based on the configuration of two diesels, the developmental B2400 model and the commercial 251 model, both manufactured by Bombardier Inc.

Researchers are using the single-cylinder version of the B2400 engine to observe engine operating parameters relating to the cylinder head and liner, fuel-injection equipment, valve system, piston, and combustion effect. The single-cylinder 251 engine is being used to test cylinder head designs and designs for optimizing the piston bowl and injector nozzle.

The work has been carried out in phases. Previous phases qualified the engines for research applications, developed correlation factors between the single-cylinder and multi-cylinder engines, and brought the test facility to operational status. In the current phase of the project, researchers are refining the design of the test facility, converting the 251 engine to a lubricating oil evaluation model, and completing and installing a turbocharger rig begun in a previous phase.

Contractor: Bombardier Inc., Montreal, Quebec

Report: TP 8395E, Bombardier single-cylinder medium-speed research engine and test facility – Phase III: Qualification, Bombardier Inc., 1987

Schedule: October 1986 - June 1988

Funding:	TDC	$300 000
	EMR – Energy R&D Program	$100 000
		$400 000

Project Number: 6797
File Number: D 1465-372-2-4
Project Officer: Roy S. Nishizaki

Rail Fatigue Life Improvement

Problems of wear on wheels and rails have been largely alleviated by the development of improved metals, the introduction of self-steering trucks, new grinding techniques, and the use of lubricants. Lubricants, in particular, have reduced wear to such a degree that some major railway companies no longer consider wear a problem requiring rails to be replaced. Instead, the main cause of rail replacement has become rail corrugation on tangent and curved track. Corrugation is caused by contact fatigue, which in turn is promoted by lubrication.

Results of an earlier project into rail wear and contact fatigue, conducted jointly by TDC and the Association of American Railroads, suggested a new method of rail grinding. Where the rails are built from premium grade steel and are thoroughly lubricated, preventive grinding should keep the rail free of surface cracks and corrugations. However, more knowledge is needed about the interaction between lubricant and metal at the contact fatigue crack tips, its effect on the rate of crack propagation, and the effects of the interaction between impurities in the metal and the plastic flow of the metal on fatigue-crack initiation.

In this project, researchers are generating quantitative data on contact fatigue in experimental and commercial steels containing known impurities. The data will be used to provide guidance for the commercial development of steels that are more resistant to contact fatigue. The researchers will also study the effects of several different combinations of lubricant additives on the development of contact fatigue.

The National Research Council's Wheel/Rail Test Facility will be used to test the selected steels. Results of the tests will be correlated with the results from field tests conducted by CN Rail.

Contractor: National Research Council, Ottawa, Ontario

Report: None to date

Schedule: June 1986 - June 1988
Funding: TDC $40 000
Project Number: 6715
File Number: D 1465-474
Project Officer: Doug W. Dibble

Rail Grinding Optimization: Phase 3

Extending rail life offers reduced transportation costs for export items such as wheat and natural resources. TDC has been supporting research using conventional rail grinding equipment to develop a ground rail profile that will reduce rail corrugation, shelling, and side wear.

During the first phase of this research program, field trials were conducted to formulate rail grinding specifications for optimum track curving performance. Researchers developed an asymmetrical ground rail profile design incorporating preventive maintenance techniques to extend rail life in curves and decrease wheel wear and fuel consumption.

The second phase of the program validated the ground rail profile design through field tests. The objectives of the third phase of the program are:

- to monitor the grinding operations for consistency, and the design profile for long-term performance;
- to develop new criteria for wear limits on continuous-welded rail;
- to develop a simple gauge for field verification of grinding performance; and,
- to examine the implications of introducing a preventive maintenance grinding program involving more frequent, but more efficient and productive grinds involving fewer passes and increased over-the-rail speeds.

Researchers are applying the preventive program at three test sites on B.C. Rail track, while three similar sites on CP Rail track are being subjected to the current, less frequent grinding practice. Rail head loss, surface cracking, rail lubrication, and sub-surface cracking and plastic flow are being monitored. Cross sections of the rail from all six sites will be analyzed at the National Research Council's Western Laboratory.

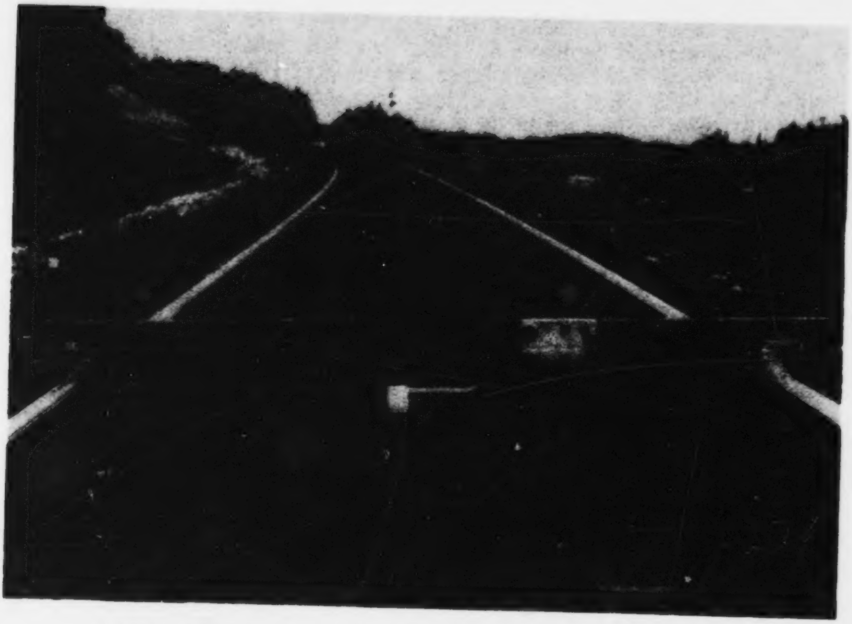
Another TDC-sponsored study examined the possibility of developing rail grinding equipment suitable for the Canadian light- and heavy-rail market. Researchers evaluated existing and projected rail grinding requirements of both railroad and transit operations and defined performance criteria for a machine that would best serve both industries.

Contractors: Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Reid, Crowther & Partners Ltd., North Vancouver, British Columbia

National Research Council (Western Laboratory), Vancouver, British Columbia

Report: None to date



View of gauge used for field verification of grinding performance

Schedule: May 1986 - May 1989

Funding:	TDC	$162 500
	CP Rail	(in kind) + $57 500
	Supply and Services Canada	$25 000
	Reid, Crowther & Partners Ltd.	$25 000
	B.C. Rail	(in kind)
	National Research Council Canada	(in kind)
		$270 000

Project Number: 6631
File Number: D 1465-368-4/5
Project Officer: Wayne G. Rowan

Laser Vision System for Rail Inspection: Phase 1

Accurate and rapid measurement of transverse rail-head profile and longitudinal rail-surface profile is essential to a cost-efficient and safe rail management system. At present, rails are inspected and measured manually. This requires a great amount of time and allows the possibility that rails in need of replacement might be overlooked.

CP Rail previously spent two years testing optical scanners but concluded that the scanners could not adequately meet all of its needs. Researchers are now working on a laser vision system, based on technology developed at the National Research Council (NRC). Laser scanners are ten times more accurate than optical scanners.

TDC, in cooperation with CP Rail, is supporting a three-phase program aimed at developing a laser vision system mounted on a track geometry car for inspecting rails at high speed. The system must be capable of providing accurate measurements of the transverse rail-head profile and rugged enough to withstand the physically harsh rail environment.

In the first phase of the development program, researchers will subject a camera, based on the NRC technology and developed by Servo-Robot Inc. of Boucherville, Quebec, to environmental, vibration, and shock tests in the laboratory. The researchers will identify and estimate the cost of changes required to enable the camera to survive in the rail environment and to perform at faster scanning and frame rates. The results of this work will be assessed before proceeding with subsequent phases involving prototype construction and field trials.

Contractor: CP Rail, Department of Research, Montreal, Quebec

Report: None to date

Schedule: April 1988 - April 1989
Funding: TDC $135 750
CP Rail $135 750
$271 500
Project Number: 7020
File Number: D 1465-523
Project Officer: Doug W. Dibble

Wheel/Rail System Test Facility

In a past project, TDC supported the development of the terms of reference for a full-scale, multipurpose test facility for new rail equipment. The terms of reference were developed into a preliminary concept by DSL Dynamic Systems Ltd. of St. Laurent, Quebec. The concept was further developed by the National Research Council (NRC) into a preliminary design for a full-scale, multipurpose wheel/rail test facility. Such a facility would allow the NRC to respond more effectively to the research and development needs of Canadian industry.

The objectives of the current project were to complete the detailed design, and to manufacture and install the wheel/rail test rig. The rig will permit full-scale tests of wheel/rail interaction, brakes, and bearings under controlled conditions. The rig features a standard wheelset with the rail element represented by a roller. It is being housed in a building constructed by the NRC at its Vehicle Dynamics Laboratory in Uplands, Ontario. The rig is also portable, allowing it to be transported to the cold chamber of the NRC Climatic Engineering Facility for research requiring controlled environmental conditions.

The design drawings are finished and components are being fabricated and assembled. The rig is expected to be ready for commissioning in the fall of 1988.

Contractor: National Research Council, Ottawa, Ontario

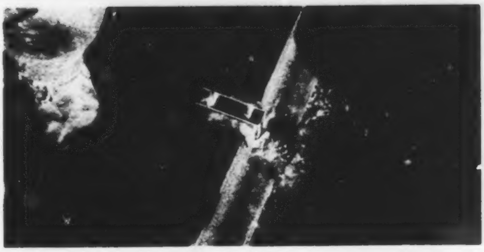
Report: None to date

Wheel/rail test rig under assembly

Schedule: June 1985 - August 1988
Funding: NRC $680 000
TDC $300 000
$980 000
Project Number: 6748
File Number: D 1645-380-2
Project Officer: Roy S. Nishizaki

Groove on rail

Adding registry marks



Mold over groove

Mixing epoxy

Waiting for epoxy to set

Sequence showing how a cast is made at a Witness Groove test station

Rail Wear Measurement

Self-steering trucks on railway freight cars are known to significantly reduce wheel wear. Some tests have shown wheel wear is three times lower on self-steering trucks than on conventional trucks. However, there is little conclusive evidence from the field of comparable reductions in rail wear because there are too few fleets of self-steering trucks in service. Exact data on rail wear is necessary to demonstrate that the savings accruing from the use of self-steering trucks are sufficient to offset the initial additional cost of the trucks.

An opportunity to test the equipment in service arose in 1984, when B.C. Rail inaugurated the Tumbler Ridge line. Almost 75 percent of the Tumbler Ridge fleet is using the DR-1 self-steering truck.

In this project researchers are measuring the reduction in rail wear on the Tumbler Ridge line that can be attributed to the use of the DR-1 self-steering truck.

Rail wear is being measured over three years. Several rail research organizations are participating in the project, and three separate rail-wear measuring techniques are being used. CN Rail's profilometer is being used to measure rail profiles twice a year at 228 test sites. The Association of American Railroads has provided equipment and personnel to measure rail temperatures before, during, and immediately after the passage of a train. The National Research Council's Western Laboratory is helping to analyze data collected from the Witness Groove test of rail wear. This test involves scratching the rail surface, making epoxy casts of the scratched surface before and after five or six train passes, then analyzing the casts to determine rail wear.

Control data will be obtained at a site with similar traffic patterns but where a fleet is using standard 100-ton, three-piece trucks.

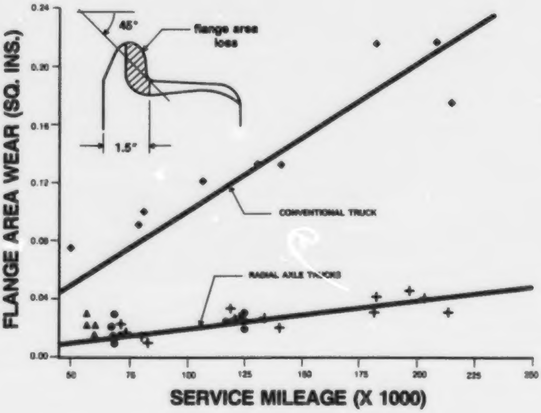
Contractor: British Columbia Railway, Vancouver, British Columbia

Report: None to date

Schedule: **June 1985 - March 1989**
Funding: **TDC $94 725**
Project Number: **6312**
File Number: **D 1465-317-24**
Project Officer: **Doug W. Dibble**

Schematic of a self-steering truck

Comparison of loss of wheel flange cross-sectional area for conventional and radial axle trucks



In-Service Radial Truck Evaluation: Phase 4

In the late 1970s, CP Rail began a test program to obtain quantitative data on the performance of various radial trucks. The results of this work to date have demonstrated that radial trucks offer: increased fuel savings due to decreased rolling resistance; decreased wheel flange wear; and, decreased maintenance of truck components. Radial trucks can be effective in reducing lateral curving forces and angle of attack while maintaining stability at high speeds. (Angle of attack reflects the degree of rail/wheel misalignment and is a key factor in wheel and rail wear.) Currently, CP Rail is directing considerable research effort towards testing two radial truck designs, Dofasco's DR-2 and the Barber Radial.

In this phase of the project researchers are gathering quantitative data on the comparative performance of conventional and radial axle freight car trucks. Parameters being evaluated include wheel wear, operational characteristics, and component performance.

One-half of a unit coal train has been equipped with Barber radial trucks and the other half with DR-2 trucks. This train has accumulated more than 150 000 miles of operation. An analysis of wheel removal statistics for the train has not revealed any substantial difference between the two types of trucks in flange and tread wear. However, when compared with wheel removal statistics for reference cars fitted with conventional trucks, car-miles-per-removal was 13 times greater for shells of radial truck wheels than for shells of conventional truck wheels.

The Barber Radial truck hunted at speeds above 50 mph during the tests. A stiffer primary rubber shear pad was added. This modification reduced the carbody hunting amplitude but did not fully eliminate the lateral oscillations of the truck, further modifications are planned.

Inspections of the DR-2 truck revealed deterioration of the elastomeric pads. The pads have been upgraded and are being retrofitted to the in-service trucks.

Contractor: Canadian Pacific Limited, Montreal, Quebec

Report: (*Draft*) Radial truck tests, Volume 4, 1987, Canadian Pacific Limited, 1988

Schedule: January 1987 - June 1988
Funding: EMR - Energy R&D Program $44 500
Project Number: 6834
File Number: D 1465-108-11
Project Officer: Doug W. Dibble

Fabricated High-Speed Rail Truck

In 1984 the federal government and the province of Quebec signed an Economic and Regional Development Agreement (ERDA). This project responds to the ERDA mandate of strengthening the transportation equipment manufacturing sector in Quebec through research and development activities aimed at bringing new products to market.

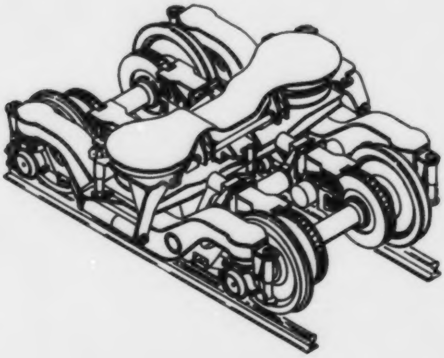
The objective of the project is to develop and test a fabricated rail truck suitable for high-speed, main-line passenger operations on intercity and commuter routes.

Researchers have developed a conceptual design for a truck. The design incorporates features of the latest truck technology available worldwide which are suited to the North American market. Ease of maintenance was an important consideration. The design is modular, allowing for easy replacement of parts, and eliminates hidden service points through such features as outboard bearings. Elements of the concept were demonstrated using a one-eighth scale model.

Current research involves the construction of two prototype trucks for field testing in 1988-89. A truck frame will also be built and subjected to shock and vibration tests.

Contractor: Bombardier Inc., Montreal, Quebec

Report: *(Draft)* Bogie mécano-soudé pour applications interurbaines, Bombardier Inc., 1988



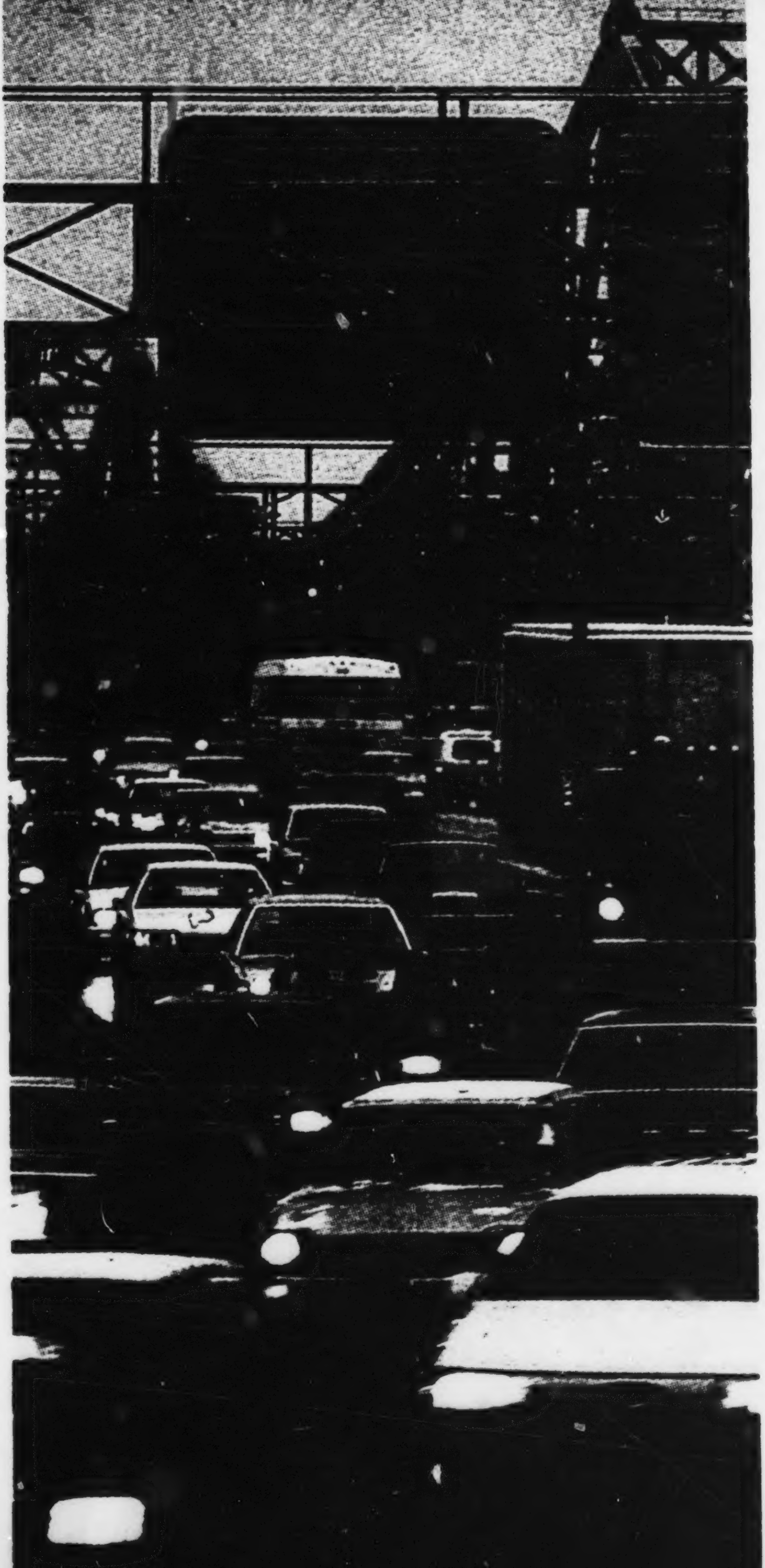
View of model of a fabricated truck

Schedule: December 1986 - March 1991

Funding:	Bombardier Inc.	$1 430 000
	Ministère des Transports du Québec	$1 035 000
	Transport Canada	$1 035 000
		$3 500 000

Project Number: 6775
File Number: D 1465-497
Project Officer: C. Alfred Versailles

SURFACE TECHNOLOGY



SURFACE TECHNOLOGY

TDC's surface transportation technology program supports research and development for a range of vehicle types including trucks, buses, off-road vehicles, light rail transit cars, and magnetically levitated vehicles. The program also supports research aimed at removing barriers to transportation for elderly and disabled persons. For the purposes of this directory, TDC's research projects in this area are grouped under five headings:

- highway vehicles and vehicle systems
- highway operations
- urban transportation
- tracked levitated technology and off-road vehicles
- transportation for elderly and disabled persons.

Highway Vehicles and Vehicle Systems

For several years TDC has been working on a number of intercity bus technology projects. These include research into a longer intercity bus, advanced suspension systems, the quality of air in buses, and wheelchair access. Two current projects draw on the findings of past work to develop and demonstrate, on Canadian highways, a new generation of intercity bus. In one project a new 45-foot intercity bus, which could become an industry standard for North America, is being developed in conjunction with a Manitoba bus manufacturer. The other project, funded by the Canada-Quebec Economic and Regional Development Agreement, is a major in-service demonstration of articulated buses over a Montreal-Quebec route.

The safety, productivity, and competitiveness of interprovincial trucking continues to concern TDC. Current projects look at increasing productivity through the application of expert systems and the introduction of new communications links.

Highway Operations

In Canada, most goods and people travel on highways. The highway system is the backbone of the country, and highway maintenance poses demanding technical problems. Improved productivity for commercial users of the highway system will benefit both the national economy and individual Canadians. Yet Canada's highways are predominantly a provincial responsibility. Accordingly, most of TDC's highway research is undertaken jointly with the provinces and with industry, and in collaboration with the Roads and Transportation Association of Canada, in an attempt to foster a coordinated national approach to highway R&D and to minimize total system costs. Some projects, such as the weigh-in-motion system, will lead to commercial equipment with domestic and export market potential.

Urban Transportation

Although urban transportation is a municipal and provincial concern, TDC is supporting projects in this field which contribute to federal government objectives such as energy efficiency, safety, and the expansion of Canada's technology base. In one project, funded by the Canada-Quebec Economic and Regional Development Agreement (ERDA), researchers are developing a generic subway car body that could be adapted to the transit requirements of cities around the world. Other projects involve applying microprocessor technology to traffic management systems, investigating vehicle diagnostic systems, and adapting a novel transmission system to urban buses.

Tracked Levitated Technology and Off-Road Vehicles

The term tracked levitated vehicle technology applies to non-contact suspension, guidance, and propulsion of transportation vehicles. The most notable application of this technology is the use of linear induction motors (LIMs) for propulsion of the Vancouver Skytrain and the Scarborough Automated Light Rail Transit systems. TDC was involved in the initial studies regarding the application of LIM technology to rail vehicles, and is currently supporting work to study the application of LIM technology to passenger and baggage transfers at airports, low-capacity people movers, and material movement in warehouses.

Major development programs of an electrodynamic Maglev system using linear synchronous motor propulsion and an electromagnetic system using linear induction motor propulsion are underway in Japan and West Germany, respectively. Maglev systems are of interest to Canada since they promise safe, fast, and efficient operations with minimal environmental impact. In the past TDC has studied the application of Maglev technology to high-speed transportation in Canada. Current work is directed towards monitoring technological developments in Japan and West Germany. The Japanese Maglev system is of particular interest because it provides for a levitation height of 15 cm, a height that allows for the snow and ice conditions found in Canada.

Several other possible transportation applications in both the surface and marine modes have been identified for Maglev technology. However, their development is not practical with existing superconducting magnets. Recent breakthroughs in high-temperature superconductor technology may resolve these application problems. TDC, in collaboration with the National

Research Council, is supporting a program to monitor the development progress toward practical, high-critical-temperature ceramic oxide superconductors on a worldwide basis.

Surface Transportation for Elderly and Disabled Persons

Transport Canada is committed to seeking ways to remove barriers to the mobility of elderly and disabled Canadians. To this end, TDC is fostering the development of equipment that allows all Canadians equal access to the nation's transportation systems — surface, marine, and air. The surface transportation projects are described in this section of the directory. Work to make air transportation more accessible to elderly and disabled persons is described in the air technology section.

Buses are the most readily available means of intercity public transportation for most Canadians. However, most intercity buses are not easily accessible for wheelchair travellers. Previous TDC work resulted in an elevator-type lift device for new buses which provides safe and dignified access for disabled persons. The technology will be evaluated during a demonstration of a completely accessible service. This demonstration represents the culmination of several years of R&D into intercity bus accessibility. Other projects are looking at station-based boarding systems for intercity buses. The station-based system is an essential element of full bus accessibility since it is not practical to retrofit elevator-type lifts into existing fleets.

Computer-assisted reservation and scheduling systems have been shown to improve special transit services. Researchers are making refinements to the DART Manager Graphics program, which is the result of several years of development and demonstration of software programs for scheduling and brokerage purposes. Brokerage systems are designed to coordinate the supply of special transit services and increase transportation efficiency. The essential element of brokerage systems is information sharing — sharing information among different service providers about client trip needs and about the delivery capability of the participating services.

New research in this area includes developing a driving simulator to facilitate independent travel for mobility impaired persons.

Prévost H5-60 articulated bus

Articulated Intercity Bus Demonstration

In 1979 TDC supported a study by Voyageur Inc. of the feasibility of using articulated buses for intercity service in Canada. The study led to the operational testing of a European-made bus on a Voyageur route. The bus was unsuited to the Canadian environment but the test program generated interest in the idea of a Canadian-made articulated bus. With the financial assistance of the federal and Quebec governments, Prévost Car Inc. of Ste-Claire, Quebec, developed a prototype of a technically advanced articulated bus, the Prévost H5-60, which is now in production.

The current project, funded under the Canada-Quebec Economic and Regional Development Agreement, is helping to support the deployment of the H5-60 in operational service. In the first phase, researchers tested the H5-60 prototype for two months, logging more than 50 000 km over various Voyageur routes. The bus was found to be reliable and suited to Voyageur's needs. The ability of the bus to manoeuvre in garages, terminals, maintenance facilities, and parking lots was also confirmed.

The second phase of the project involves a two-year service demonstration using up to 20 of the buses on Voyageur's Montreal-Quebec route. The demonstration is scheduled to begin in November 1988, using 12 buses. The remaining buses will be added during the second year of the demonstration.

The Prévost articulated bus offers the possibility of renewed economic viability for intercity bus transportation. The demonstration will test passenger response to a new level of comfort and spaciousness in intercity bus service. The articulated buses to be used in the demonstration have one single and one double seat per row. They carry 48 passengers in a space that could accommodate 72 in a standard seating configuration.

Voyageur is developing a comprehensive data gathering system for the demonstration. Many special surveys and studies are planned. The researchers will compare the technical and economic performance of the H5-60 with that of a control group of new standard coaches in Voyageur's fleet. Multimodal market research before and during the demonstration will measure changes to travel habits on the route.

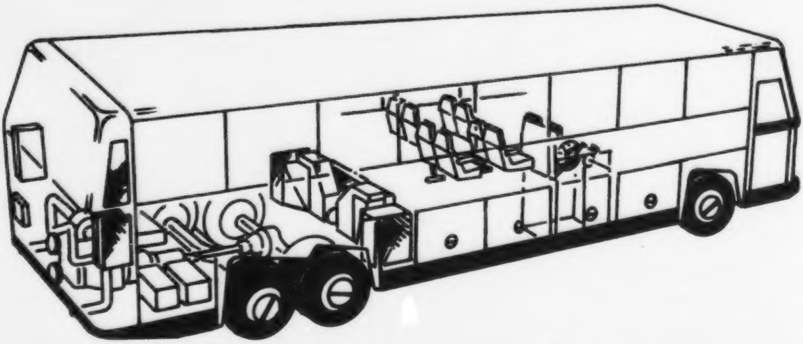
Contractor: Voyageur Inc., Montreal, Quebec

Report: TP 8826F, Rapport d'évaluation et d'épreuves d'endurance du prototype de l'autocar articulé H5-60 de Prévost Car — phase I, Voyageur Inc., 1987

Schedule: October 1987 - March 1991

Funding:	Transport Canada	$2 449 000
	Ministère des Transports du Québec	$2 449 000
		$4 898 000

Project Number: 6942
File Number: D 1465-490-4
Project Officer: Brian Marshall



Concept sketch of one of the configurations investigated in the feasibility study

Mock-up of an accessible washroom designed for the prototype

45-foot Intercity Bus Development

In an earlier study, TDC established the technical and operational feasibility of using longer buses on intercity routes. Based on that work, Motor Coach Industries Ltd., of Winnipeg, submitted a proposal to develop a 45-foot bus incorporating many of the bus technology and accessibility features investigated under TDC's intercity bus R&D program during the past few years.

This three-phase development program will bring a new bus design to the prototype stage ready for demonstration to operators and regulatory authorities. Emphasis will be placed on economy, passenger comfort, and accessibility for elderly and disabled travellers. The 45-foot bus could become the new industry standard for North America.

In the first phase, researchers are looking at accessibility, suspension, and air quality. Planned accessibility features include washroom access for disabled passengers, bus compatibility with a station-based lift system, and an optional internal lift for boarding wheelchair travellers. A suspension simulation model developed by UTDC Inc. of Kingston, Ontario, is being used to evaluate the performance of alternative suspension configurations featuring such innovations as active damping. The model will be used to design the chosen configuration. Researchers will also design a heating, ventilation, and air-conditioning system to provide the highest practical ratio of fresh air to recirculated air.

In the second phase, a 40-foot bus will be modified to serve as a test vehicle for sub-system development. Critical components will be evaluated on the test vehicle and specifications developed for the 45-foot bus.

The third phase will involve detailed design, fabrication, and testing of a fully equipped prototype. Quantitative data on the performance of the suspension system will be gathered to assess the effectiveness of using a simulation model as a design tool.

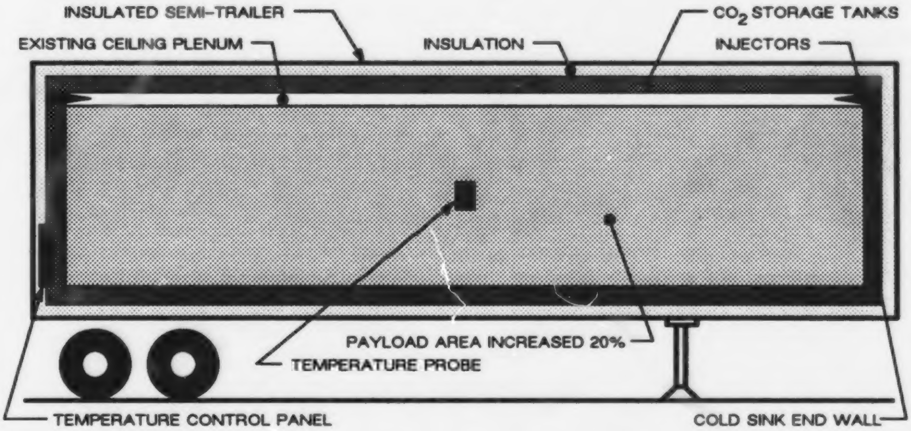
Contractor: Motor Coach Industries Ltd., Winnipeg, Manitoba

Report: From previous work: TP 8233E, Feasibility of an accessible longer intercity bus, Beauchemin-Beaton-Lapointe Inc., 1986

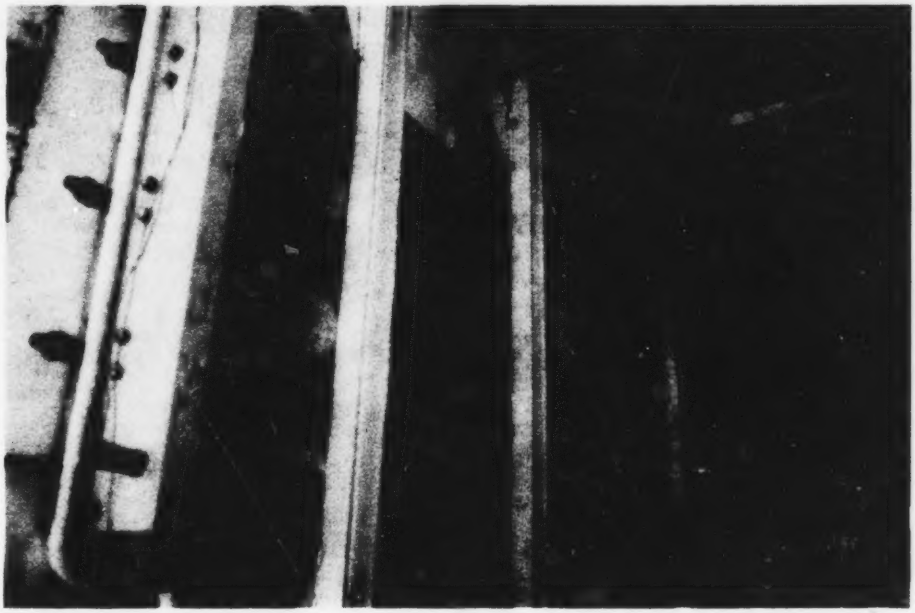
Schedule: March 1987 - October 1989

Funding:	Supply and Services Canada	$480 000
	TDC	$160 000
	EMR - Energy R&D Program	$160 000
	TDPP	$160 000
		$960 000

Project Number: 6981
File Number: D 1465-472-3
Project Officer: Brian Marshall


INSULATED SEMI-TRAILER
EXISTING CEILING PLENUM
INSULATION
CO_2 STORAGE TANKS
INJECTORS
PAYLOAD AREA INCREASED 20%
TEMPERATURE PROBE
TEMPERATURE CONTROL PANEL
COLD SINK END WALL

Sketch of cold spray/cold sink system for truck trailers



Part of a laboratory prototype of a carbon dioxide refrigeration system

Carbon Dioxide Refrigeration System For Trucks

Refrigerated trucks carry 85 percent of the nearly 10.5 million tonnes of perishable foods transported in Canada each year. It is essential to the agriculture, fishing, and meat industries that these foods be delivered to the market in the freshost possible condition. Unfortunately, breakdown of compressors and other mechanical components of truck refrigeration systems often results in costly spoilage.

Carbon dioxide (CO_2) cryogenic refrigeration, which does not rely on moving parts, is considered potentially better and more reliable than the mechanical refrigeration systems currently used. However, CO_2 technology has not yet been exploited for application to truck refrigeration systems.

This project has three objectives: to develop, test, and demonstrate a CO_2 refrigeration system suitable for long-haul trucks; to evaluate the effectiveness of the system; and to define a CO_2 distribution network to serve trucks in Canada.

The contractor developed and tested adaptations of two existing CO_2 refrigeration systems. One is a "cold spray" system that injects CO_2 snow into the cargo space when needed to maintain the required temperature. The other is a "cold sink" system that varies CO_2 pressure in a closed system to attain the required temperature. A laboratory prototype of the favoured adaptation will be demonstrated.

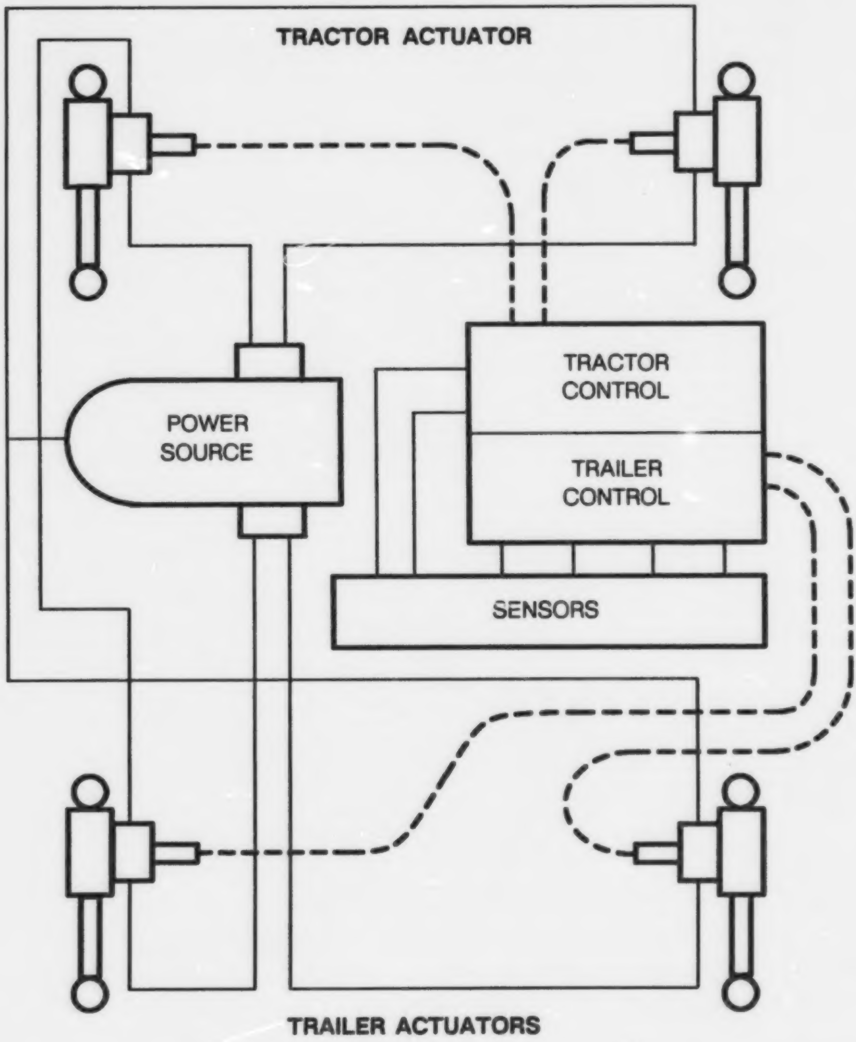
Contractors: Fridev Refrigeration Systems Ltd., Brossard, Quebec
Concool Refrigeration Ltd., Pointe Claire, Quebec

Report: None to date

Schedule: November 1985 - December 1989

Funding:		
	EMR – Energy R&D Program	$259 000
	TDC	$60 000
	Agriculture Canada	$50 000
	Supply and Services Canada	$40 000
		$409 000

Project Number: 6495
File Number: D 1465-455
Project Officer: Lewis Sabounghi


TRACTOR ACTUATOR
POWER SOURCE
TRACTOR CONTROL
TRAILER CONTROL
SENSORS
TRAILER ACTUATORS

Schematic diagram of a dynamic suspension system for heavy articulated vehicles

Active Suspensions for Heavy Vehicles

Vehicles carrying heavy loads cause significant damage to Canadian highways. The damage could be reduced through the use of dynamic load distribution mechanisms or active suspension systems. An active suspension system may also provide important economies in fuel consumption. Conventional suspension systems isolate a vehicle's sprung mass from the road, protect the cargo, and meet the static loading requirements of various road authorities. An active suspension system, in addition to meeting these needs, could permit a heavy vehicle's suspension characteristics to be modified according to road conditions and load. Many high-performance automobiles have used some form of active suspension for a number of years, but little research has been done in using these suspensions on heavy vehicles.

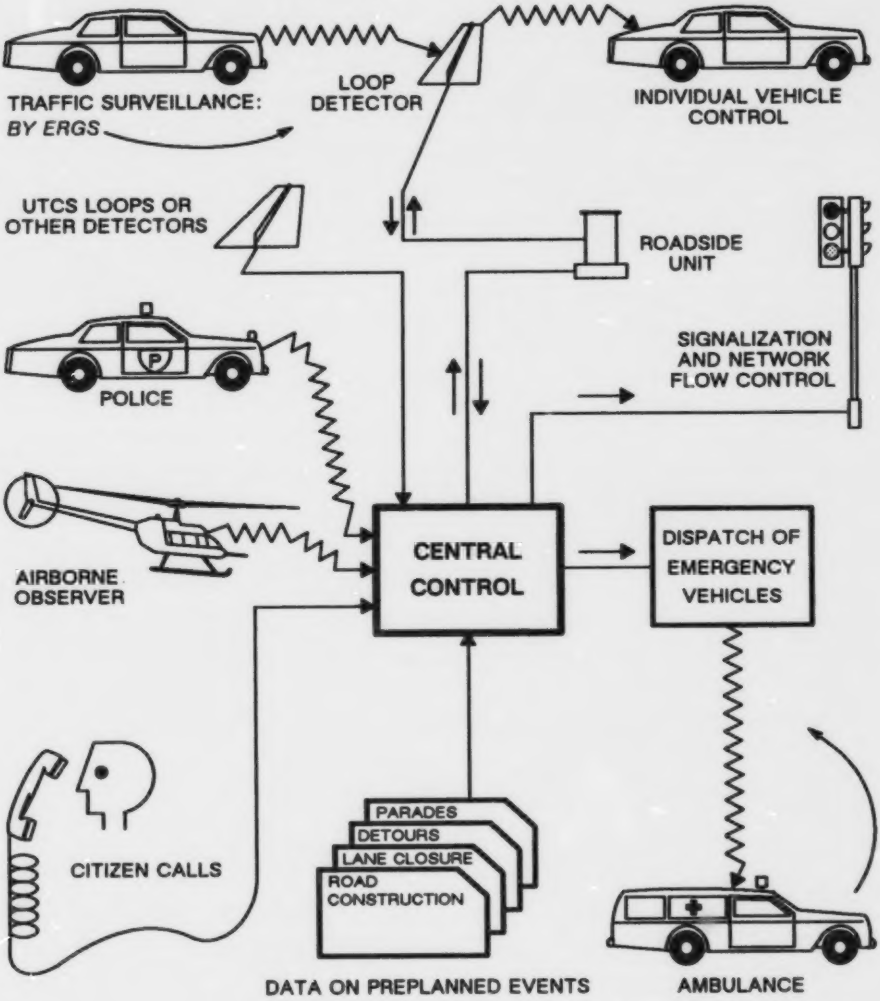
The goal of this project was to assess the potential performance of an active suspension system for heavy vehicles in terms of vehicle economy, safety, and comfort, and in terms of highway maintenance costs.

Researchers conducted a literature search and reviewed the dynamic road-holding characteristics of conventional heavy vehicle suspensions and the infrastructural and operating costs associated with heavy vehicles. The study indicates that use of active suspension systems in heavy vehicles would likely result in less road damage, fewer accidents, and lower operating costs.

Contractor: C.E. Berthiaume Technologies Inc., Ottawa, Ontario

Report: TP 8399E, A study of active suspensions for heavy vehicles, C.E. Berthiaume Technologies Ltd., 1987

Schedule: June 1986 - October 1987
Funding: TDC $49 000
Project Number: 6732
File Number: D 1465-484
Project Officer: Lewis Saboungi


TRAFFIC SURVEILLANCE:
BY ERGS
LOOP DETECTOR
INDIVIDUAL VEHICLE CONTROL
UTCS LOOPS OR OTHER DETECTORS
ROADSIDE UNIT
SIGNALIZATION AND NETWORK FLOW CONTROL
POLICE
P
AIRBORNE OBSERVER
CENTRAL CONTROL
DISPATCH OF EMERGENCY VEHICLES
CITIZEN CALLS
PARADES
DETOURS
LANE CLOSURE
ROAD CONSTRUCTION
DATA ON PREPLANNED EVENTS
AMBULANCE

ERGS (Electronic Route Guidance System) concept: one of the technologies reviewed

Mobile Information Systems: Impact Study

Small Canadian trucking companies will have to make use of the most modern technologies if they are to remain efficient and competitive in an open market. Mobile information systems are one such technology.

In a separate project *(page 47)* TDC has commissioned a study of the various radio-navigation (navaid) services likely to be available to the year 2000. Emphasis is being placed on identifying the potential benefits of navaid devices for surface transportation industries.

In this project researchers reviewed technologies that are currently available commercially or that are under development, and that provide some form of in-vehicle location display such as electronic maps or navigation aids. The researchers identified applications for the transportation marketplace and possible roles for government in regulating the technologies, developing standards, and promoting research and development.

The final report is being prepared. Based on the preliminary findings, TDC is considering supporting a follow-up project to study in greater detail the potential for mobile information systems.

Contractor: Jouko A. Parviainen and Associates, Oakville, Ontario

Report: *(Draft)* Mobile information systems impact study,
Jouko A. Parviainen and Associates, 1988

Schedule: January 1987 - June 1988

Funding:	TDC	$30 000
	Ministry of Transportation, Ontario	$30 000
		$60 000

Project Number: 6824
File Number: D 1465-494
Project Officer: Lewis Saboungh**i**

Knowledge-Based Vehicle Dispatcher's Aid

To be successful, commercial road transport operations must route and schedule vehicles effectively. Conventional computer-based dispatching systems are often inefficient. The trucking industry relies on the experience of dispatchers to keep track of a large number of changing variables. Dispatchers must have a knowledge of highway regulations, geography, weather, vehicle characteristics, labour codes, collective agreements, safety measures, and customer requirements. Knowledge-based, or expert, systems could help dispatchers by freeing them from time-consuming, lower-level decisions.

In 1986 Applied AI Systems Inc. examined the application of a knowledge-based system to transportation management. A preliminary study of the integration of an expert system into dispatching procedures was conducted with Canadian Liquid Air (CLA), with positive results.

The current project aims at developing and demonstrating an expert decision-aid system in CLA's dispatch office in Hamilton, Ontario. The system will incorporate the practical knowledge of a CLA employee who is experienced in dispatching tanker trucks to deliver dangerous goods to customer sites. Researchers are using the NEXPERT development tool from Neuron Data Inc. for the data base file, and working with the CLA expert to formulate various application rules.

Successful completion of this project could offer a dispatching aid prototype to serve as a model for other companies.

Contractor: Applied AI Systems Inc., Kanata, Ontario

Report: None to date

Schedule: June 1987 - June 1988

Funding:	Supply & Services Canada		$58 000
	EMR - Energy R&D Program		$50 000
	CLA	(in-kind) +	$30 000
			$138 000

Project Number: 6900
File Number: D 1465-509
Project Officer: Lewis Saboungi

A Study of Future Canadian Radio-Navigation Systems

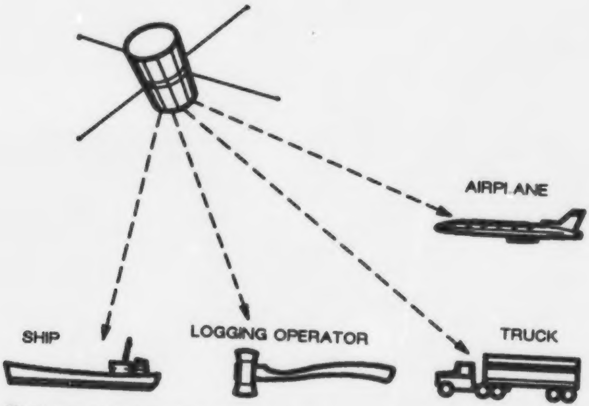
Radio-navigation systems support the safe and efficient movement of people, resources, raw materials, and manufactured goods. Traditionally, the equipment required to use these systems was too expensive and too bulky to be considered for widespread use in small vehicles. Recent advances in micro-electronics and microprocessor technologies offer the possibility of low-cost, easy to use, and accurate position-location and navigation or route-finding systems. These systems are attractive for surface vehicle operations and non-transportation applications. Provinces, forestry organizations, trucking operators, and cartographers have all expressed an interest in the emerging technology.

Surface users, therefore, will probably become a major influence in the deployment of navigation aids during the next decade. This may have an impact on Transport Canada's provision of radio-navigation (navaid) services.

TDC has commissioned a study of the navaid services likely to be offered to surface users to the year 2000, and of the needs of those users. The study will describe the magnitude of the Canadian requirement and will suggest a coherent approach to the use of navaids in Canada.

Contractor: Thompson-Hickling Aviation Inc., Ottawa, Ontario

Report: None to date



Radio navigation aids for locating position can benefit land, sea and air operators.

Schedule: September 1987 - October 1988
Funding: TDC $30 000
Project Number: 6931
File Number: D 1455-112-10
Project Officer: Barry B. Myers

Control of Drifting Snow on Highways

Blowing and drifting snow is a hazard for drivers on many Canadian highways. It is also costly for travellers, truck operators, and highway maintenance crews, especially when roads are closed by snow conditions.

The objective of this project is to improve existing methods of controlling drifting snow and to develop new designs and placement strategies for snow fences.

Researchers catalogued Canadian snow drifting problems and selected 35 sites that typified one or more of the problems. The sites were located in Ontario, Quebec, New Brunswick, the Yukon, and the Northwest Territories. Each site was photographed and analyzed, and remedial solutions were recommended. The solutions were implemented before the winter of 1987-88 and the sites were observed during the winter to determine the effectiveness of the solution.

The results of the work will be incorporated into a manual of winter highway maintenance practices.

Contractor: Rowan, Williams, Davies, & Irwin Inc., Guelph, Ontario

Report: None to date

Appropriately placed snow fences will reduce snow drifting across highways. Photographic records and snow depth measurements of sites permit evaluation of remedial action.

Schedule: January 1987 - November 1988

Funding:	Supply and Services Canada	$92 000
	Policy and Coordination Group (Transport Canada)	$25 000
	Yukon	$20 000
	Northwest Territories	$19 000
	TDC	$15 000
	Indian and Northern Affairs Canada	$10 000
	Parks Canada	$10 000
		$191 000

Project Number: 6805
File Number: D 1465-498
Project Officer: Doug W. Dibble

Low-Cost Weigh-in-Motion System

Detailed information about the type and weight of vehicles using highways is important to highway agencies in the planning, design, and development of systems to meet future needs; in the cost-effective maintenance of existing roads; and, in the implementation and enforcement of vehicle regulations. Weigh-in-motion (WIM) systems provide the only practical means of gathering comprehensive data on a continuous basis. Such systems are, however, expensive: a four-lane system costs approximately $300 000. New technology — in particular a piezo-electric cable sensor — could offer substantial cost reductions.

The objective of this project was to develop and demonstrate a multi-lane WIM system based on piezo-electric technology. The cable sensor is a semi-rigid coaxial cable filled with piezo-electric ceramic powder. When compressed, the powder generates an electrical charge between the outer copper sheath and a wire running through the centre of the cable. The potential developed is proportional to the pressure and area affected; installed in a road surface, the cable can be used to measure a vehicle's axle weight. Researchers modified existing traffic counter/classifier electronics to integrate these components into a system using the piezo-electric cable.

The provinces of Saskatchewan and Ontario participated in the project by providing test sites and installation services. The main prototype system was installed on Highway 7N near Toronto, close to an existing traffic data collection station; measurements taken by the prototype were compared with the conventional unit. The first cables were installed in October 1986 and additional sensors added in June 1987. The performance of the system met all expectations, demonstrating an accuracy approaching that of conventional equipment. The contractor is taking orders for an axle load classification system based on the success of this project.

Contractor: International Road Dynamics Inc., Saskatoon, Saskatchewan

Report: *(Draft)* Development and demonstration of a low cost weigh-in-motion scale system for highway applications, International Road Dynamics Inc., 1988

Schedule: October 1986 - June 1988

Funding:	Supply and Services Canada		$84 292
	International Road Dynamics Inc.		$65 000
	TDC		$52 500
	Province of Ontario	(in kind) +	$50 000
	Province of Saskatchewan		(in kind)
			$251 792

Project Number: 6787
File Number: D 1465-492-2
Project Officer: Brian Marshall

High Precision Weigh-In-Motion Scale

The more authorities learn about the damage caused to highway infrastructure by high axle loads, the more interested they become in monitoring truck weights and enforcing axle load limits. As larger and heavier vehicles are allowed on Canadian roads, highway authorities will have to make a greater effort to police overweight vehicles.

Traditionally, regulations have specified a single load limit for a multi-axle group on a vehicle. This type of regulation is no longer adequate. Authorities must now consider the loading on individual axles. Weighing of individual axles on a single static scale is inefficient. Multi-platform scales, designed to weigh all axles individually, are expensive.

In this project researchers are developing and testing a reasonably priced system for weighing individual axles in motion at slow speed with the precision required for the enforcement of highway weight regulations.

The system will weigh individual axles and calculate gross vehicle weight. Vehicles can travel over the scales at speeds of up to 10 km/h. The researchers are considering the use of various sensor technologies, including piezo-electric cables, piezo-electric mylar, force sensor resistor film, and a bending plate with strain gauges.

Contractor: International Road Dynamics Inc., Saskatoon, Saskatchewan

Report: None to date

Schedule: February 1988 - February 1989

Funding:	TDC	$163 000
	International Road Dynamics Inc.	$56 000
	Province of Saskatchewan (in kind)	+ $20 000
		$239 000

Project Number: 7208
File Number: D 1465-492-3
Project Officer: Sesto Vespa

Generic High-Capacity Subway Car Body

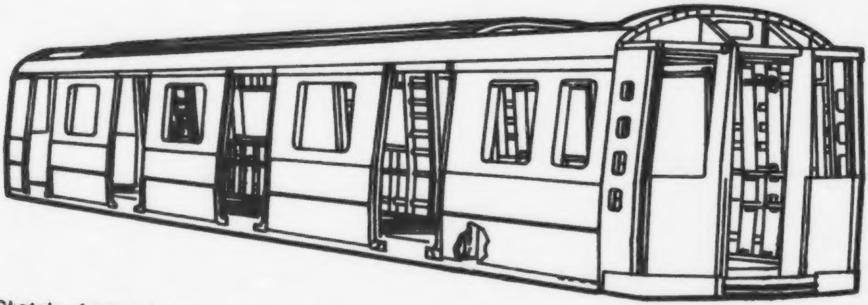
Canada has developed a world market for subway cars, but maximum exploitation of this market is hampered by the need to design a new vehicle for each application. Local manufacturers can offer vehicles with an operational history, whereas the Canadian design is perceived as unproven. The objective of this project is to develop and build a generic subway car body that can be adapted to the needs of transit companies around the world. The work is being supported with funds from the Canada-Quebec Economic and Regional Development Agreement.

A generic car body would allow the manufacturer to respond quickly to orders for cars to run on any truck and track configuration. The experience gained with any model of the generic car would serve to prove the design of the car in the marketplace. Fixed design features include body materials and fabrication techniques, heating and air conditioning standards, a range of exterior dimensions, and a range of seating capacities. The conceptual design has been created on a CAD/CAM system to facilitate adaptation of the basic features to specific customer demands.

The conceptual design is currently being reviewed by Transport Canada and the Quebec transport department.

Contractor: Bombardier Inc., Montreal, Quebec

Report: *(Draft)* Caisse métro grand gabarit, Bombardier Inc., 1988



Sketch of generic subway car body

Schedule: December 1986 - March 1989

Funding:	Bombardier Inc.	$1 222 000
	Transport Canada	$889 000
	Ministère des Transports du Québec	$889 000
		$3 000 000

Project Number: 6854
File Number: D 1465-505
Project Officer: C. Alfred Versailles

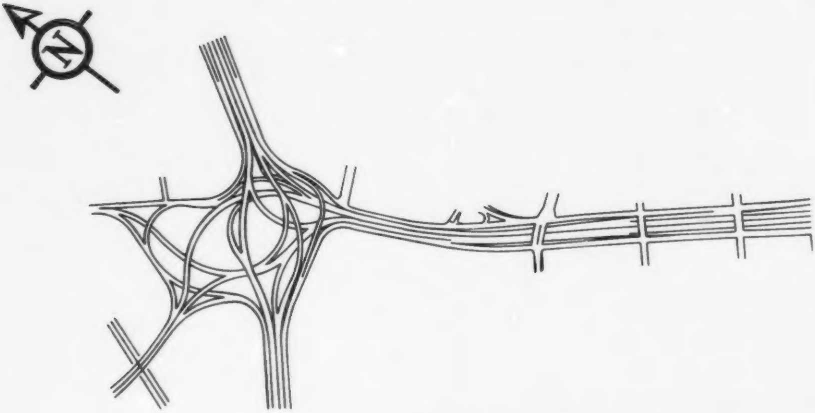
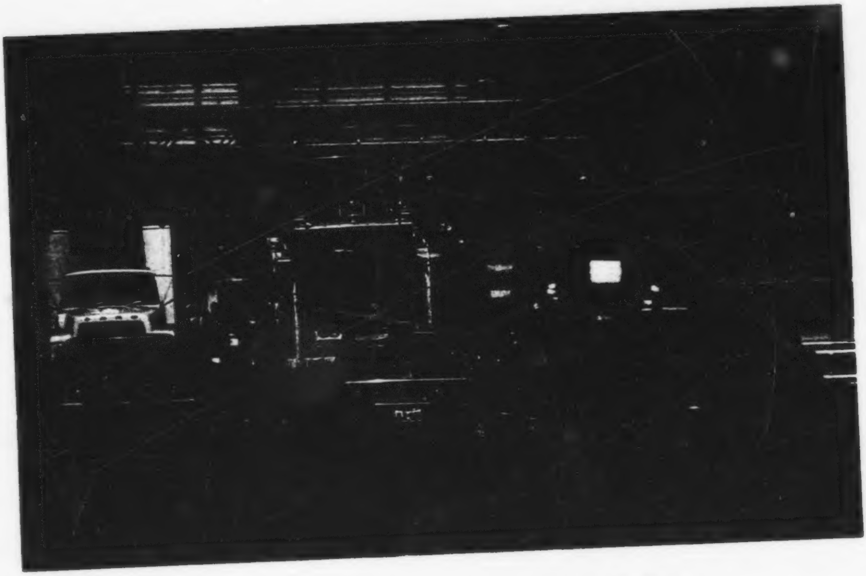


Diagram of typical interchange addressed in the project



Integrated traffic systems can improve traffic flow

Freeway Traffic Flow Management

Efficient movement of vehicles on urban freeways requires that congestion be minimized, traffic flow be maintained at moderate speeds, and supporting functions such as control at access ramps, emergency rerouting, and driver instruction signs be effective.

The objective of this project was to study the feasibility of developing a freeway management system for heavily congested routes in Montreal. The work was supported with funds from the Canada-Quebec Economic and Regional Development Agreement. The routes selected were Autoroute 25, the Metropolitan, Decarie, and Ville Marie expressways, the Bonaventure Autoroute, and the Champlain Bridge. The researchers wanted to improve traffic flow without constructing new infrastructure.

The researchers reviewed the effectiveness of existing traffic rules, evaluated possible methods of directing drivers through traffic congestion, and identified several workable traffic management techniques that might increase a route's capacity.

Recommendations were formulated. Those judged by highway authorities to provide the greatest benefit relative to cost were an automatic incident detection system and electronic message boards to inform drivers of route changes. The report also recommended specific sections of the routes investigated to be covered by the system and a timetable for implementation.

If the proposed techniques prove to be successful, they will provide some relief of current Montreal congestion and will provide valuable insights into traffic flow applicable to other urban corridors.

Contractor: SNC/DeLuC Co-entreprise, Montreal, Quebec

Report: TP 8955F, Étude de faisabilité d'un système de gestion de circulation pour les corridors autoroutiers A-25/Métropolitaine/Décarie/Ville-Marie/Bonaventure/Pont Champlain, SNC/DeLuC Co-entreprise, 1987

Schedule: June 1986 - August 1987

Funding:	Transport Canada	$125 000
	Ministère des Transports du Québec	$125 000
		$250 000

Project Number: 6661
File Number: D 1465-462-2
Project Officer: Douglas Whitehead

Microcomputer-Based Integrated Traffic System

Efficient traffic control can increase the capacity of existing roads and highways; reduce vehicle energy consumption by reducing the number of stops and starts; improve the level of service to drivers by reducing delays and congestion; improve safety through better accident analysis; and, reduce the cost of maintenance through better use of resources. The advent of the microcomputer and the development of several standard traffic analysis programs provide traffic engineers with some of the tools necessary for efficient traffic regulation, including the ability to easily re-time signals. Yet the programs that are available have not been integrated into an operational control system and there is no data base that can be conveniently used to calibrate such a system.

An earlier project concluded that an integrated traffic system could offer significant benefits. In the current project, researchers are developing an integrated system and evaluating it in three locations in Ontario: Toronto, Ottawa-Carleton, and the Regional Municipality of Durham. The researchers reviewed traffic operations in each of the cities and prepared criteria for the necessary data base. They also reviewed commercially available traffic analysis programs and hardware. Based on this work they developed and tested an integrated system and prepared supporting documentation for users and operators.

The system is being implemented in each of the locations. Evaluations will be conducted from fall 1988 to spring 1989 and an assessment will be made to highlight benefits and possible opportunities for improvement.

Contractor: IBI Group Inc., Toronto, Ontario

Report: None to date

Schedule: January 1987 - December 1988

Funding:	Ministry of Transportation, Ontario	$157 000
	EMR - Energy R&D Program	$150 835
		$307 835

Project Number: 6819
File Number: D 1465-444-2
Project Officer: John H. Morgan

Vehicle Diagnostics Study

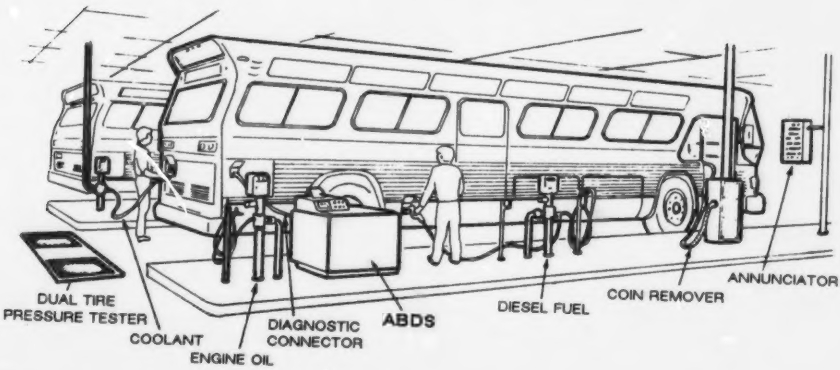
Vehicle diagnostics systems (VDS) are installed in vehicles to monitor and report on the performance of key mechanical functions of the vehicle. An emerging trend in vehicle maintenance, VDS technology has the potential to improve efficiency, reliability, and vehicle readiness, and reduce maintenance costs through failure prediction.

In 1987 the Ministry of Transportation, Ontario (MTO) commissioned a study of VDS. The study concluded that VDS could provide significant advantages for public transportation vehicles.

This project is exploring the possible use of VDS in transit vehicles. It is being undertaken on behalf of the Canadian Urban Transit Association under a Transport Canada-MTO Memorandum of Understanding on Transportation R&D. Researchers will compare the needs of transit fleets with the specifications of existing VDS. The findings of this study will be used to identify opportunities for application of existing or enhanced VDS to Canadian transit vehicles.

Contractor: TransVision Consultants Ltd., North Vancouver, British Columbia

Report: *(Draft)* An evaluation of vehicle diagnostic systems for buses, TransVision Consultants Ltd., 1988



Sketch of an automatic bus diagnostic system (ABDS) in action. The overall health of a bus is checked daily during refueling.

Schedule: August 1987 - July 1988
Funding: TDC $27 325
Project Number: 6743
File Number: D 1465-488
Project Officer: John H. Morgan

Ker-Train Transmission for Buses

In 1982 Ker-Train Systems Ltd. of Kingston, Ontario, developed a unique, incrementally variable transmission (IVT) for use in electric vehicles. It featured a 64-step transmission with regenerative capability, maximum torque output of 574 N•m at 166 r/min, a microprocessor control system, and an overall efficiency of 95 percent. The transmission was successfully demonstrated over two years in a Marathon C-360 electric van. A subsequent study concluded that an IVT could provide fuel savings of up to 30 percent in an urban bus.

Ker-Train is now developing and building an IVT for use in a new armoured personnel carrier. The work is being done under a contract with the Department of National Defence (DND). Some of the engine and vehicle specifications are similar to those of urban buses.

The objective of this project is to develop and manufacture a prototype IVT transmission for an urban bus.

TDC is supporting the design and fabrication of the transmission and the engineering required to install it in an urban bus. The Ministry of Transportation, Ontario, is supporting the installation of the transmission in the bus, the testing and in-service demonstration, and the documentation and analysis of the results.

Ker-Train will take advantage of its work for DND. This exploitation of the DND requirement permits the introduction of the IVT to a commercial market which has been unable to support the cost of a full-scale development program.

Contractor: Ker-Train Systems Ltd., Kingston, Ontario

Report: None to date

Schedule: January 1988 - January 1990

Funding:	EMR – Energy R&D Program	$200 000
	TDC	$88 000
		$288 000

Project Number: 6871
File Number: D 1465-507
Project Officer: John H. Morgan

Arctic Snowmobile Development

The recreational snowmobile used in southern Canada is also widely used in the North for transport and trapping operations. In fact, the snowmobile has become essential to the economies of most northern communities, and a more reliable snowmobile would offer real benefits to these communities. Since 1983 TDC has been collaborating with the Inuit organization Nunasi Corporation to design and develop a rugged utility snowmobile that could be assembled in the North with a life expectancy of ten years and a price comparable to that of recreational snowmobiles. Two prototype vehicles have already been developed and tested.

In this project, researchers implemented the recommendations resulting from trials of the prototype in the North. The specific goals were: to modify the front and rear suspensions for better handling; to investigate the use of composite materials in structural elements to reduce weight; and, to evaluate methods of providing flotation in the event of accident.

The suspension modifications have been successfully tested and incorporated into the design. Ten pre-production models of the snowmobile are operating in the North. The contractor is studying the commercial aspects of marketing the vehicle.

The use of lightweight materials, a smaller engine, and flotation devices was found to be impractical in the existing vehicle. However, the contractor incorporated these features in a pre-prototype snowmobile that is 25 percent lighter than the previous model. It is constructed of lightweight, composite material and aluminum. Bouyancy is built into the design.

Contractor: Nunasi Corporation, Ottawa, Ontario

Report: TP 9168E, Arctic snowmobile development: lightweight materials research for suspension systems and flotation, Nunasi Corporation, 1988

View of pre-production Arctic snowmobile with improved suspension

Schedule: March 1987 - June 1988
Funding: TDC $80 000
Project Number: 6853
File Number: D 1465-320-4
Project Officer: Jacques E. Laframboise

Superconducting Technology Monitoring

TDC has for a number of years supported long-term, exploratory activities relating to non-contact suspension, guidance, and propulsion of transportation vehicles. Part of this work related to a tracked, magnetically levitated (Maglev) system. Maglev systems are of interest to Canada since they promise safe, fast, and efficient operations with minimal environmental impact. A key element in the Maglev — the superconducting magnet — is a major barrier to Maglev development from both an economic and technical point of view.

With the recent introduction of a new generation of superconductors capable of operating at higher temperatures using inexpensive liquid nitrogen (earlier, lower-temperature superconductors required liquid helium), the possibility of new propulsion and levitation technologies for transportation system applications must again be considered.

TDC and the National Research Council (NCR) are collaborating on a program to monitor the development progress of practical high-critical-temperature ceramic oxide wire and tape superconductors worldwide. Of particular interest are advances in high-critical-temperature superconductors suited to the large-scale magnets needed for transportation applications.

A recent review by NRC identified several possible future applications for practical superconductors in transportation systems including:

- Electrodynamic Maglev vehicle suspension.
- Air-core linear synchronous motors for guided ground transport vehicle propulsion, e.g. electrodynamic Maglev vehicle propulsion, subway train adhesion-independent propulsion, and rail locomotive adhesion-independent auxiliary propulsion for climbing steep grades.
- Electromagnetic thrusters for ship application. This concept was introduced in the mid 1960s and abandoned owing, in part, to the inability to generate the very high magnetic fields necessary for reasonable propulsion efficiency.
- Superconducting coil energy storage for electric road vehicles.
- Electrodynamically suspended and electromagnetically propelled catapult sled launching of aircraft as a method of alleviating traffic congestion at airports without the capital cost and land usage penalties associated with the construction of new runways.

TDC's planned program to monitor superconductor research worldwide will facilitate engineering feasibility assessments of identified application needs as new wire and tape development performance data becomes available.

Contractor: National Research Council Canada, Ottawa, Ontario

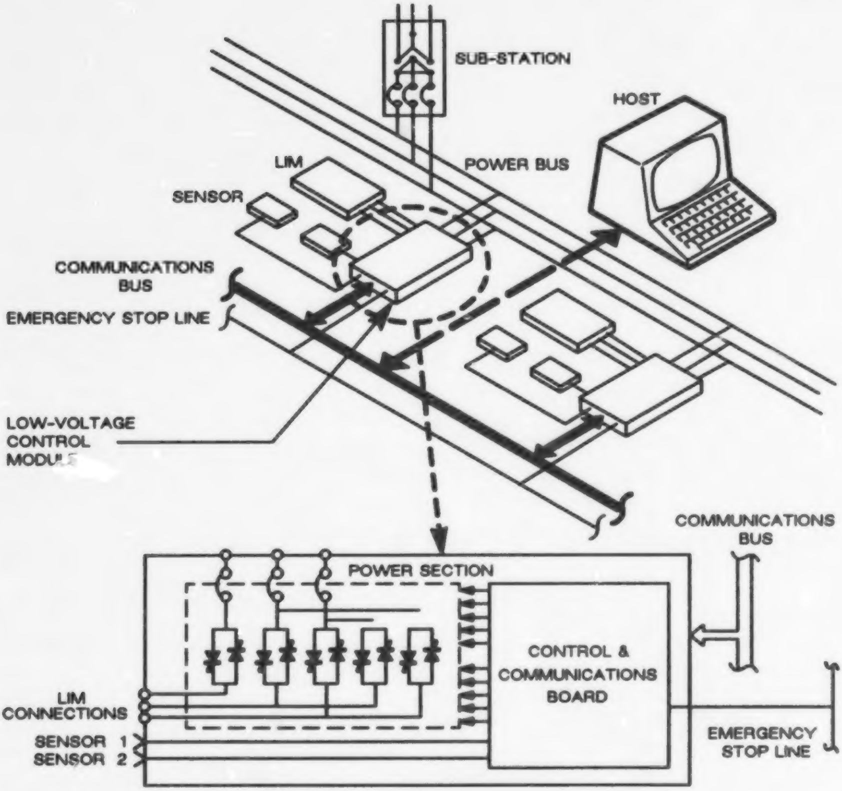
Report: *(Draft)* Summary report on the potential impact of new high-critical-temperature ceramic oxide superconductors on transportation systems, National Research Council, 1988

COOLING MEDIA FOR HIGH-CRITICAL-TEMPERATURE SUPERCONDUCTORS

Cooling Medium	Temperature	η_c	Features
Liquid Helium	4.2°K	1.42%	Expensive Limited Supply
Liquid Hydrogen	20.3°K	8.0%	Highly Combustible
Liquid Neon	27.1°K	11.0%	Expensive
Liquid Nitrogen	77.0°K	39.3%	Inexpensive

η_c = REFRIGERATION SYSTEM CARNOT EFFICIENCY = $\frac{T}{(T - T_0)}$

Schedule: January 1988 - July 1988
Funding: TDC $20 000
Project Number: 6276
File Number: D 1465-269-4
Project Officer: Maurice Audette


SUB-STATION
HOST
LIM
POWER BUS
SENSOR
COMMUNICATIONS BUS
EMERGENCY STOP LINE
LOW-VOLTAGE CONTROL MODULE
COMMUNICATIONS BUS
POWER SECTION
CONTROL & COMMUNICATIONS BOARD
LIM CONNECTIONS
SENSOR 1
SENSOR 2
EMERGENCY STOP LINE

LIM-in-track propulsion configuration. Sensors are located on both sides of the LIM so that the train can be detected from either direction.

Advanced Linear Induction Motor and Propulsion Control

TDC has supported research into the linear induction motor (LIM) since 1979. The Vancouver Skytrain rapid transit system introduced in 1986 is a prime example of Canada's leadership in LIM technology. This non-contact propulsion technology offers scope for other novel transportation and industrial applications. Already being considered are low-power people movers for transportation terminals, material-handling systems, and production lines. Of particular interest are LIM configurations featuring passive vehicles: the LIM primaries are located in the track, while the traction member is located on the vehicle. These configurations allow the track to be flush with the floor, removing obstacles to foot traffic and wheeled vehicles.

The objective of this project was to further the development of variable frequency LIM technology in three areas: microprocessor power control, slip-power recovery, and LIM self-steering.

In present configurations, each LIM in the track is connected directly to a power control panel, requiring a number of cables along the track. Relays switch the motors on and off as required. Microprocessor power control permits the use of a single bus-bar for selecting power.

Existing LIM drives suffer some power loss due to slippage as the reaction rail passes over the LIM primary. If this slip power could be recovered, it could be applied to charging on-board batteries, lighting, braking, and steering. A preliminary assessment supported the possibility of slip-power recovery and identified specific work to be done in this area.

Finally, researchers presented a novel concept for vehicle steering based on wire guidance.

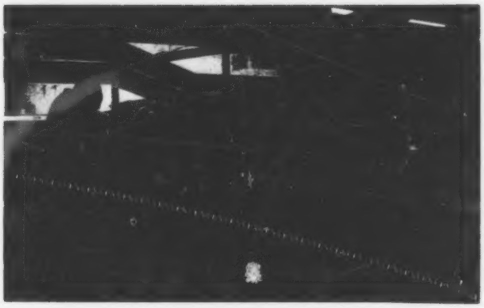
Contractor: UTDC Inc., Kingston, Ontario

Report: TP 9308E, Linear induction motors and their control systems, UTDC Inc., 1988

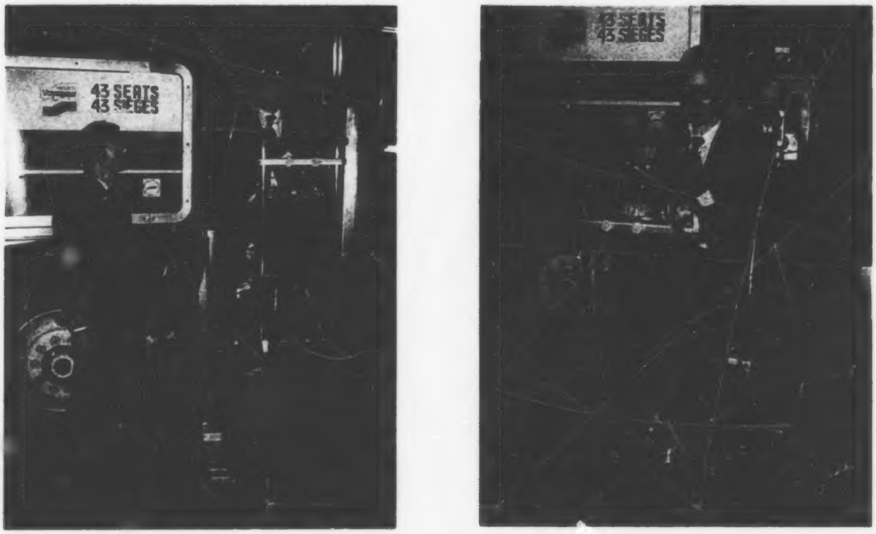
Schedule: November 1985 - March 1988

Funding:	TDC	$300 000
	Supply and Services Canada	$200 000
		$500 000

Project Number: 6599
File Number: D 1465-427-2
Project Officer: C. Alfred Versailles



Model of folding ramp concept for a station-based access system using special narrow wheelchairs


43 SEATS
43 SIEGES
43 SEATS
43 SIEGES

Model of lift featuring a powered platform to elevate special wheelchairs

Station-Based Boarding Systems for Intercity Buses

Features of standard North American intercity buses — especially their high floor, small doors, steep narrow stairs, and narrow aisles — make access difficult for disabled travellers. Internal wheelchair lifts offer a solution for new buses but are prohibitively expensive to install in existing vehicles. A need exists for a station-based device to facilitate the boarding of disabled travellers. An earlier project evaluated a boom-mounted transfer chair for use with existing bus fleets. The device proved to be unsatisfactory, but the testing experience did provide useful design criteria.

To stimulate fresh thinking about the problem, Transport Canada sponsored a design competition in 1986 for "Novel Station-Based Boarding Concepts for Mobility Impaired Travellers at Intercity Bus Depots." Fifty proposals were received. The five best proposals were awarded $5 000 contracts to complete the initial conceptual design work and to provide a scale model of the boarding system. From these submissions two concepts, both submitted by the University of Ottawa, were judged promising enough to warrant further development.

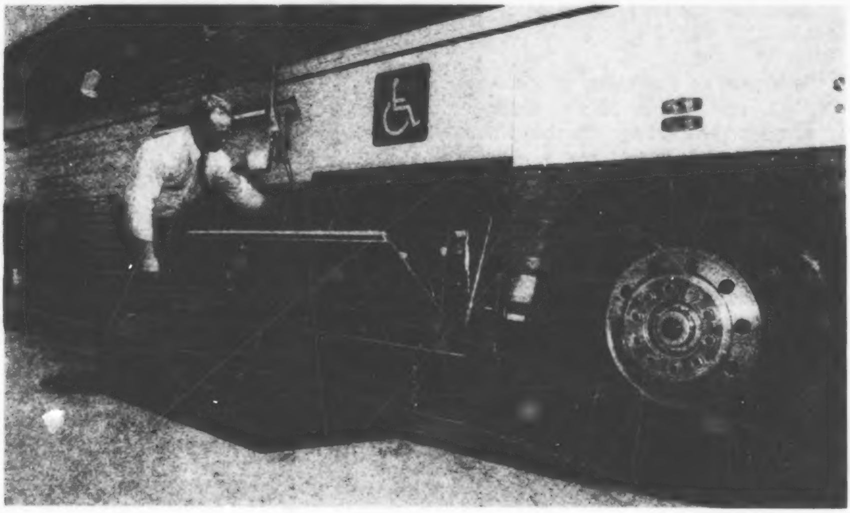
Both concepts feature a special narrow wheelchair used to transport passengers from the top of the lift to their seat location. In one concept the wheelchair is pushed up a simple folding ramp to the level of the coach floor; in the other, it is raised on a powered platform that travels on rails deployed over the coach stairs.

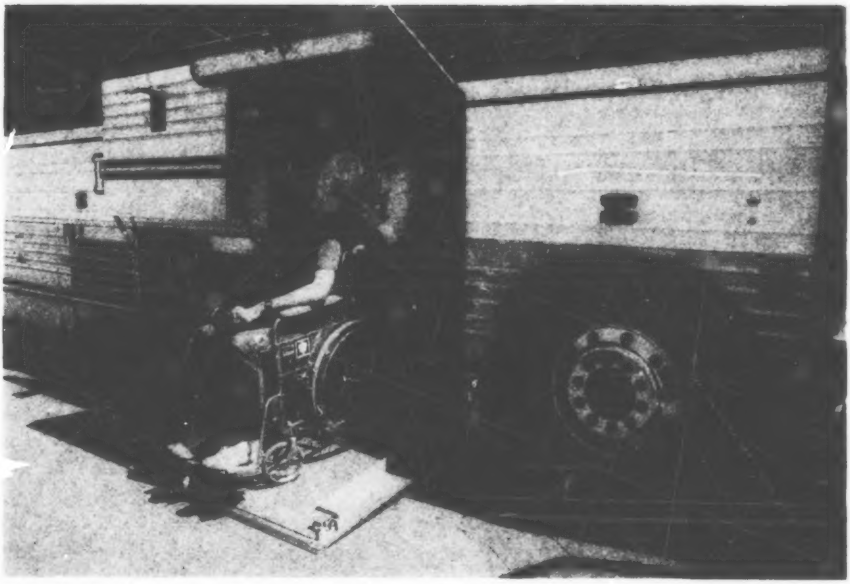
The objectives of this project are to construct full-scale working models of the two designs, to evaluate them, and to define the operational implications of their use. The results of the project will determine whether to build prototype units for an operational demonstration.

Contractor: University of Ottawa, Research Services, Ottawa, Ontario

Report: From previous work: TP 8803E, Station-based lift for intercity buses: design criteria, Delcan Corporation, 1987

Schedule: January 1988 - December 1988
Funding: TDPP $90 682
Project Number: 7012
File Number: D 1465-522-3
Project Officer: Brian Marshall





Prototype lift installation in a Prévost Mirage XL

Wheelchair Lift for Prévost Mirage XL Bus

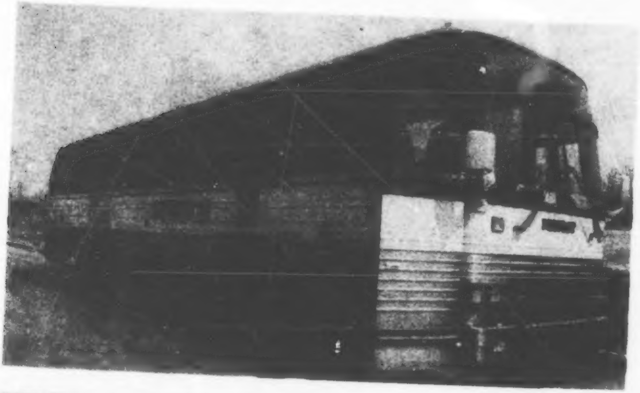
For several years TDC has supported the design of internal wheelchair lifts for intercity buses. Since 1985 a lift designed by TES Ltd. of Ottawa has been in use in Newfoundland's Roadcruiser service. In 1985 an improved design was completed. Called the Accessobus, it was demonstrated at Expo 86 in Vancouver and provided the basis for a production model. Both the Roadcruiser and the Accessobus installations were designed for Motor Coach Industries buses.

To further encourage accessibility on intercity buses, it was decided to help transfer the lift technology to Canada's other intercity bus manufacturer, Prévost Car Inc. This project facilitates the transfer and develops a third-generation lift system incorporating significant design improvements over the Roadcruiser and Accessobus installations. The improvements include: locating the entire lift assembly below the floor level; eliminating the bulky wheelchair restraint units; reducing weight and cost; and, simplifying operation of the system. The goal of the project is to develop a production standard lift that could be ordered as an option on Prévost's new Mirage XL bus.

The design and fabrication of the prototype lift installation are complete. Following testing the bus will be made available to Transport Canada for a further 12 months of evaluation and demonstration. It will also be used for publicity and training for a three-year demonstration of accessible service on Canada Coach Lines routes in Ontario *(page 66)*.

Contractor: Prévost Car Inc., Ste-Claire, Quebec

Report: None to date



Schedule: March 1987 - June 1988
Funding: TDPP $259 350
Project Number: 6873
File Number: D 1465-506
Project Officer: Brian Marshall

Accessible Intercity Bus Service Demonstration

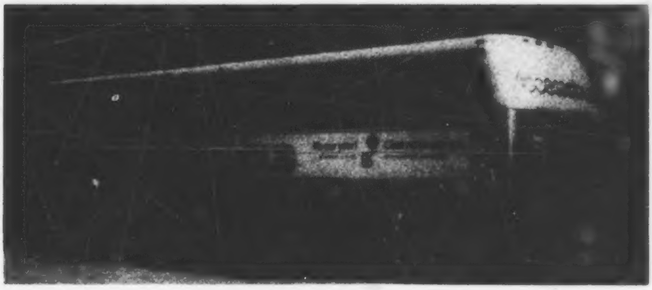
One of the objectives of a recent TDC project to develop a wheelchair lift system for the Prévost Mirage XL *(page 65)* was to provide an accessible bus for a 12-month revenue service demonstration. When the Canadian Bus Association (CBA) asked its members for suggestions for the 12-month service, a more ambitious demonstration concept was put forth. Canada Coach Lines (CCL) proposed a three-year demonstration using six buses to provide fully accessible service on their routes connecting Buffalo, Hamilton, and Kitchener/Waterloo. The CBA believes that a demonstration of this duration and scope will resolve operational issues, address economic viability, and determine whether there is a real market demand for accessible service of interest to industry and Transport Canada.

CCL will buy, with federal government assistance, six production accessible buses from Motor Coach Industries of Winnipeg. The buses come equipped with lift systems, wheelchair tie-down stations, and aids for sensory-impaired passengers. CCL will be responsible for all operating costs and will gather detailed utilization and cost data during the demonstration. TDC will provide support for planning, coordination, publicity, special surveys, and monitoring and evaluating the demonstration.

The CCL corridor is approximately 180 km long. Six buses will offer ten trips in each direction every day. The service will link five communities with local parallel transit systems and will feed into accessible transportation in the United States. Orders have been placed for the buses and the demonstration is scheduled to start in January 1990.

Contractor: Canada Coach Lines, Hamilton, Ontario

Report: None to date



Accessobus, a prototype version of the buses to be used in the demonstration

Schedule: March 1988 - March 1992
Funding: TDPP $1 185 000
Project Number: 7064
File Number: D 1465-525-2
Project Officer: Brian Marshall

Enhancement of DART Manager Graphics Software

The demand for public transportation services for disabled people is growing rapidly. As such services expand and become more complex, efficient dispatching of vehicles becomes increasingly important. TDC has supported such innovations as a computer-assisted reservation and scheduling system and a computer model for route planning. Most recently, several computer programs were developed and demonstrated which allow a central dispatcher to efficiently assign special transit services to disabled people in Vancouver. The software is known as DART Manager Plus, Versions 1.1 and 2.2, and DART Manager Graphics, Version 2.1.

The demonstrations identified a need to improve the DART Manager Graphics software and to incorporate artificial intelligence features that would make the system easier to use. Two improvements under study are a semi-automatic feature to suggest alternative vehicle assignments and an on-line help facility.

This project supports the development and demonstration of these new features. They will provide special transit operators increased efficiency and cost savings by helping to assign trips immediately upon receipt of a call.

Contractors: BC Transit, Vancouver, British Columbia
TransVision Consultants Ltd., North Vancouver, British Columbia

Report: None to date

BC Transit van. The vans are dispatched using a computer-assisted reservation and scheduling system.

Schedule: March 1985 - June 1988

Funding:		
	TDPP	$44 000
	BC Transit	$26 000
		$70 000

Project Number: 6827
File Number: D 1450-103-67-2
Project Officer: Ling Suen

Special transit van in service in Edmonton, Alberta

Computerized Scheduling and Brokerage Demonstrations, Edmonton and Vancouver: A Comparative Analysis

In 1985 TDC jointly sponsored two scheduling and brokerage demonstration projects, one with the City of Edmonton Transportation Department and the other with BC Transit in Vancouver. Both ended in March 1987.

In Edmonton, a centralized brokerage system was established using proprietary software to match client trip needs with the most cost-effective service option. Different kinds of vehicles were used, including city-owned buses, taxis, and privately operated vans. A commercially available computer system was used for the brokerage centre.

In Vancouver, BC Transit attempted to install a decentralized brokerage system that would allow individual operators to coordinate services through an electronic information-sharing network. Two computer systems were developed and installed. The electronic networking will be implemented gradually in the future.

In the current project, researchers compared the two demonstration projects in terms of organization, approach, software and hardware, implementation strategy, and results. They concluded that computerized scheduling and brokerage systems could help coordinate services and improve transportation efficiency.

Differences between the demonstrations were apparent in the analysis. The technology was further advanced in Vancouver, while Edmonton emphasized methods of addressing organizational and contractual arrangements for providing services. Vancouver's computer programs were available to other operators in Canada, while Edmonton's computer system was available only through a private company. Both demonstrations achieved increased productivity and decreased operational costs.

Contractor: TransVision Consultants Ltd., North Vancouver, British Columbia

Report: TP 8712E, Computerized scheduling and brokerage demonstrations, Edmonton and Vancouver: a comparative analysis, TransVision Consultants Ltd., 1987

Schedule: January 1987 - November 1987
Funding: TDC $27 561
Project Number: 6352
File Number: D 1450-103-60-4
Project Officer: Ling Suen

Automobile Driving Simulator

As Canada's population ages, the number of Canadians with impaired mobility increases. One objective of Transport Canada's program to make transportation accessible to elderly and disabled persons is to explore new technologies which can promote independent travel. Driving one's own car is an important step to independent travel. It can also play a significant role in the rehabilitation of people whose mobility has been impaired by accident or disease.

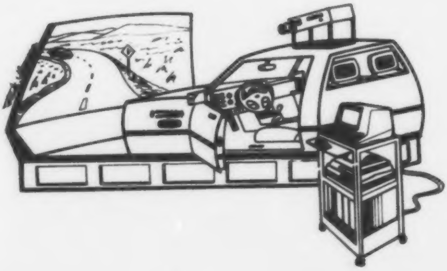
The project is aimed at developing a low-cost, high-fidelity, microprocessor-based automobile driving simulator for use in evaluating the capability of severely disabled people to drive an automobile. The simulator will present realistic driving scenarios and use sensory modules to simulate visual, tactile, and acoustic effects.

Researchers are working in cooperation with the Constance Lethbridge Rehabilitation Institute in Montreal to understand the special ergonomic needs of potential users. The simulator hardware has been assembled and partially demonstrated. Elements of the hardware are being refined and the software is being developed.

Contractors: CAE Electronics Ltd., St. Laurent, Quebec

Sub-contractor: Concordia University, Fluid Power, Control and Simulation Research Laboratory, Montreal, Quebec

Report: None to date



Concept drawing of driving simulator. The simulator uses sensory modules to simulate visual, tactile, and acoustic effects in various driving scenarios.

Schedule:	March 1987 - May 1989	
Funding:	TDPP	$265 480
	Supply and Services Canada	$215 000
	CAE Electronics	($80 000 in-kind)
		$480 480

Project Number: 6702
File Number: D 1450-103-77
Project Officer: Roy S. Nishizaki

Lightweight Electric Wheelchair

Although battery-powered wheelchairs provide greater mobility for many disabled people, they also inhibit some kinds of trips. For air travel, Transport Canada regulations permit the transport of lead-acid batteries in larger aircraft only, which means chair users travelling by smaller aircraft must arrange for batteries to be supplied at their destination. Disabled persons who drive their own cars or take taxis avoid using powered wheelchairs because they are too heavy to be easily lifted into the trunk of a car.

The objective of this project is to develop a lightweight, ergonomically sound wheelchair powered by a lightweight battery.

Researchers at B.C. Hydro and Power Authority have developed a novel wheelchair. It features: three large-diameter wheels for a more comfortable ride; a disc motor, incorporating a permanent magnet with high-energy density, built into the hub of the driving wheel; power steering controlled by a joy-stick; limited movement of the rear wheel at higher speeds, for safety; and, composite materials to permit tailoring to specific users.

The total weight of the new wheelchair is 20 kg, compared with 40 to 55 kg for conventional powered chairs. It is powered by 28 nickel cadmium "D" cells and has a top speed of 8 km/h.

Contractor: B.C. Hydro and Power Authority, Surrey, British Columbia

Report: None to date

Schedule: February 1985 - December 1988

Funding:	TDPP	$261 210
	Supply and Services Canada	$102 620
		$363 830

Project Number: 6361
File Number: D 1450-103-64
Project Officer: John H. Morgan

Portable Transfer Shell for Wheelchair Travellers

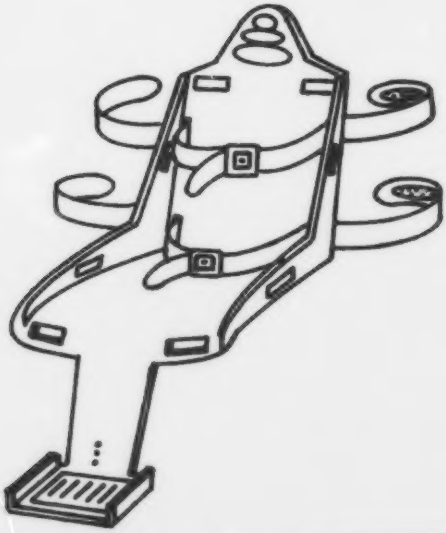
Wheelchair travellers frequently must be transferred from their wheelchair to another seat. Current transfer methods vary from lightweight chairs used by the airlines to manual lifting of the passenger. Most methods involve a degree of physical discomfort and also may be awkward and embarrassing.

In this project, researchers are developing a lightweight, personalized transfer shell acceptable to both wheelchair travellers and transportation authorities. The shell features hand holds for lifting, and straps to secure the passenger to the shell and the shell to the wheelchair or the vehicle seat. The shell can be tailored to fit individuals so that frequent travellers could purchase a shell for their travel needs.

The shell is being demonstrated to carriers and potential users.

Contractor: Shako Enr., Montreal, Quebec

Report: *(Draft)* Étude sur la faisabilité et la construction d'un prototype de coquille de voyage, Shako Enr., 1988



Sketch of portable transfer shell

Schedule: March 1987 – March 1988

Funding:	Supply and Services Canada	$55 277
	TDPP	$25 000
		$80 277

Project Number: 6619
File Number: D 1450-103-72
Project Officer: Barbara A. Smith

Multipurpose Vehicle Evaluation

It is difficult for small or isolated communities to meet the public transportation needs of elderly and disabled persons. Paratransit systems using dedicated vehicles are costly. At the same time, many communities have purpose-built ambulances that are underused: a survey taken in 1982 in Manitoba found that some ambulances received only seven calls a year.

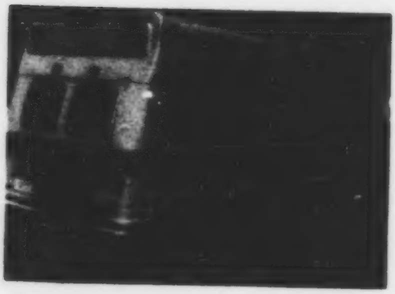
Both the federal government and the province of Manitoba have determined that paratransit and ambulance services could be more efficiently provided in small communities and rural areas by a vehicle designed to serve both purposes. In earlier projects, specifications for a multipurpose vehicle were developed and a prototype vehicle was built. The prototype was designed primarily for transporting elderly and disabled persons, but it can be quickly transformed for use as an emergency vehicle.

This project involves a demonstration service of the vehicle to evaluate its operational and economic performance.

Under the Program for Transportation of the Mobility Disadvantaged in Rural Manitoba, the rural municipality and village of Minitonas was selected for a two-year demonstration. Operating data collected for the province of Manitoba was complemented by ergonomic and mechanical evaluations and user surveys. The results of the evaluations are being analyzed. The researchers will recommend operational and technical improvements and consider the application of similar multi-use vehicles to other situations.

Contractor: Manop Services Ltd., North Vancouver, British Columbia

Report: *(Draft)* Evaluation of a multipurpose rural vehicle,
Manop Services Ltd., 1988



Multipurpose vehicle in demonstration service

Schedule: February 1987 - June 1988
Funding: TDPP $74 114
Project Number: 6823
File Number: D 1450-103-74-2
Project Officer: Barbara A. Smith

Wheelchair Securement System

An earlier project by Manop Services Ltd. of North Vancouver, British Columbia, identified the critical need for better ways of securing wheelchairs in vans and buses. A TDC survey of paratransit operators substantiated this finding. The majority of specialized transit operators across Canada use a four-point belt system that satisfies the Canadian Standards Association. However, operators complain that these belts are time-consuming to secure and are uncomfortable for the passengers. Furthermore, the belts cannot be used to secure non-conventional wheelchairs, such as scooters.

The objective of this project is to develop a more convenient securement system suitable for use with the majority of mobility devices used by disabled persons. The system must meet the requirements of specialized transit operators in terms of efficiency.

The researchers first reviewed current data on mobility devices, investigated the configurations of various vehicles used for special transit operations, and compared existing securement systems with operator requirements. They used these findings to develop two securement concepts. Operators and potential users were consulted to determine the prospects of commercial production. Based on the results of the survey, the researchers built a mock-up of the preferred concept. It is installed in a paratransit vehicle for demonstration and evaluation in the Ottawa area.

Contractor: TES Limited, Ottawa, Ontario

Report: None to date

View of new wheelchair securement system

Schedule: December 1986 - June 1988
Funding: TDPP $89 780
Project Number: 6722
File Number: D 1450-103-79
Project Officer: Barbara A. Smith

AIR TECHNOLOGY

AIR TECHNOLOGY

Canada's vast size and the distances between communities make air transportation vital to Canadians. TDC's air transportation technology program supports Transport Canada's role in air navigation, air traffic control, airport operations, and flight regulations, while stimulating cooperative R&D activities within the air industry. TDC's program has three main objectives: security — the continued application of technology to improve air security; safety — technology aimed at reducing the risk of flying; and, application R&D — adapting state-of-the art products and systems to the needs of Transport Canada procurement activities. These activities stem from implementation of the Canadian Airspace Systems Plan, which includes the Radar Modernization Program, the Flight Data Modernization Program, and the Microwave Landing System Program. TDC supports this work in collaboration with various divisions of the Aviation Group and the Airports Authority Group of Transport Canada.

Flight Safety

Included under flight safety are research efforts directed toward accident prevention, accident survivability, and improving technologies used for accident investigations to better understand the causes of accidents. Current projects address: the installation of protective breathing equipment for passengers; the development of technical criteria for improved crashworthiness of small aircraft; and, the design of a new generation of emergency locator transmitters.

Air Navigation Services

TDC's research in this area is largely concerned with research in support of the Canadian Airspace Systems Plan. Several projects are aimed at demonstrating the power of artificial intelligence tools, especially expert systems for design, analysis, and decision-making. Other projects are addressing the ergonomic aspects of air traffic control workstations.

TDC is also working with Air BC, local government organizations, and other components of Transport Canada to examine the application of microwave landing systems and short take-off and landing technology at Pemberton airport in the mountains of British Columbia.

Airports and Operations

Transport Canada's Airports Authority Group has made specific requests for R&D work. Current projects are looking at the effects of operational changes within airports, the geometry and maintenance of runways, and the capacity and productivity of existing air terminals. A major research effort relates to the development of detection and screening systems that will enhance airport and flight security without creating unreasonable boarding delays.

Air Transportation for Elderly and Disabled Persons

Canadian airports are among the most accessible in the world for elderly and disabled travellers. To maintain this leadership position, Transport Canada is committed to seeking new ways to remove barriers to mobility that still exist. TDC supports this commitment by pursuing the development of equipment that allows all Canadians equal access to the nation's transportation systems. The application of communications technology to the problems of sensory-impaired travellers has resulted in several systems that enhance air travel. Current projects are developing and demonstrating Communicaid I, Communicaid II, and Communicator/Translator.

Other projects are trying to solve the problems encountered by wheelchair travellers in boarding certain types of aircraft and in storing their wheelchairs.

Fibre-Optic Fuel Gauge for Aircraft

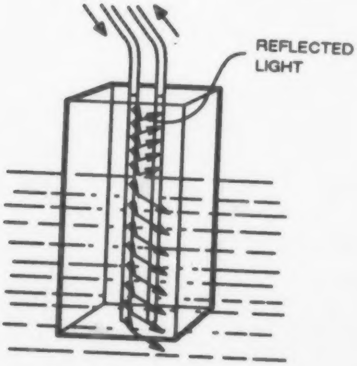
Air safety has advanced significantly in past decades; however, incremental increases in levels of safety under specific conditions are always possible. The Canadian Aviation Safety Board has identified fuel gauges as a possible area for safety improvement. Inaccurate fuel gauge readings have been a contributing cause in a number of airplane accidents. As well, fuel gauges and their probes can conduct a high surge of electricity to the fuel tank if the aircraft is struck by lightning. Fibre-optic technology offers a solution to these problems. Focal Technologies Inc. of Dartmouth, Nova Scotia, has developed an optical sensor prototype, but it does not meet the specifications for a generic aircraft fuel probe.

The objective of this project is to develop a prototype fuel measuring system based on fibre-optic technology. The design will feature fluorescent optical fibres and offers continuous fluid level sensing. Conventional gauges display only incremental liquid levels.

The contractor, in consultation with Canadair Inc. and other airframe manufacturers, will select one of the fuel measuring configurations now in use and develop a generic specification for a fibre-optic system based on that configuration. A prototype fibre-optic system will be constructed to the specification. A method of integrating the sensor and other system elements into existing airframes will also be developed.

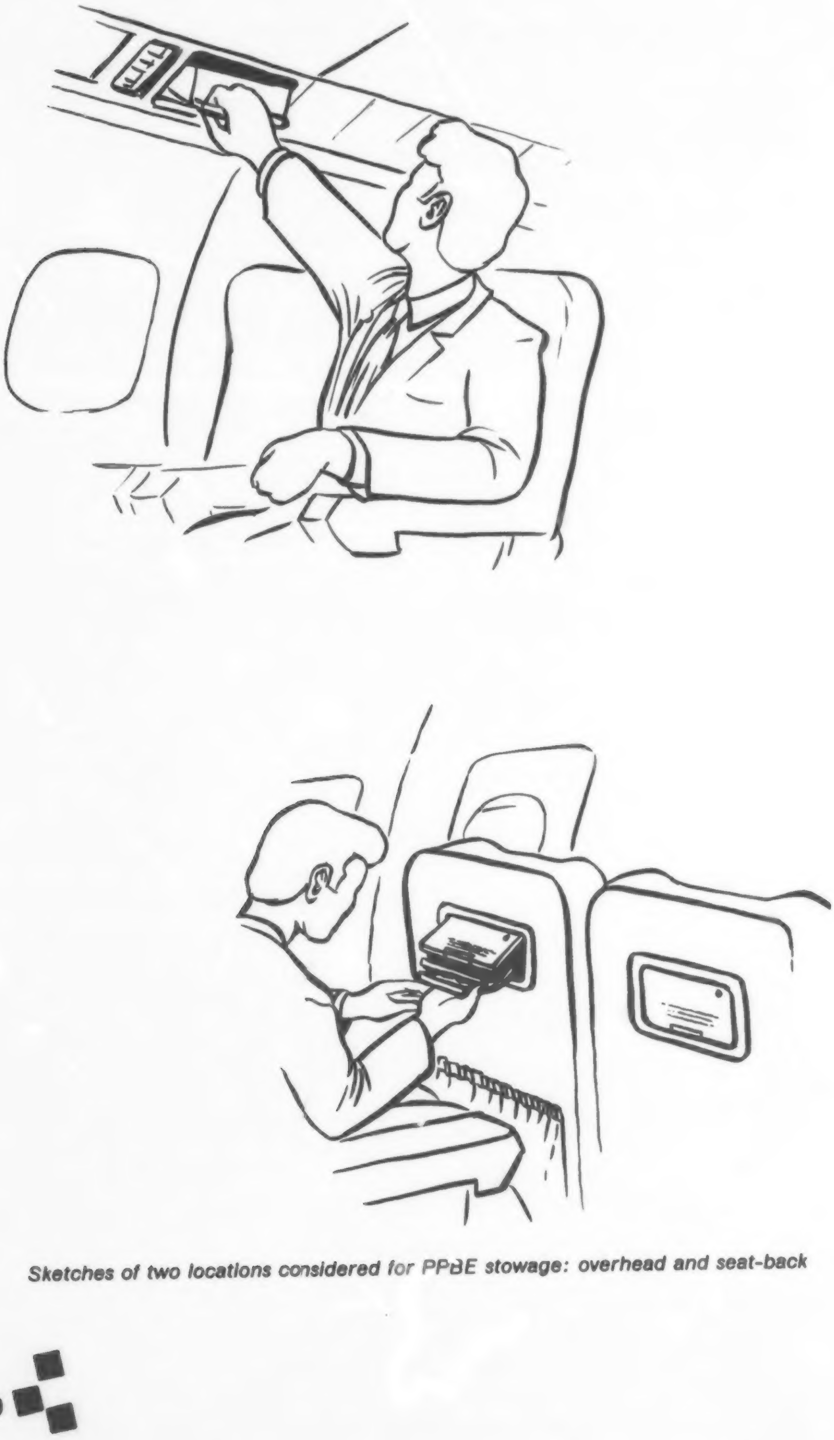
Contractor: Focal Technologies Inc., Dartmouth, Nova Scotia

Report: None to date



Schematic of continuous-liquid-level, fibre-optic sensor operation. The reflected light is absorbed to produce a signal inversely proportional to the level of the fuel in tank.

Schedule: February 1988 - September 1989
Funding: TDC $180 000
Project Number: 7021
File Number: D 1455-198
Project Officer: James D. Reid



Sketches of two locations considered for PPBE stowage: overhead and seat-back

Passenger Protective Breathing Equipment: Stowage and Presentation

Air passenger safety technology has advanced significantly through the years, but further improvements are always possible. One area where improvements can still be made is in protecting passengers from the smoke and toxic gases produced by on-board fires. Airworthiness authorities in Canada, the United States, the United Kingdom, and France are cooperating to study concepts and technology for passenger protective breathing equipment (PPBE). As part of Transport Canada's contribution to this on-going effort, TDC is supporting a series of research projects.

The first project, conducted in 1984 by the Ontario Research Foundation, evaluated various PPBE commercially available. The results of these evaluations are being used by the Airworthiness Branch of Transport Canada's Aviation Group to develop a PPBE specification.

The objective of the current project is to define stowage and presentation concepts for PPBE on turbine transport aircraft in passenger service. The criteria for the project were developed by the Airworthiness Branch.

Researchers reviewed the interior configurations of various aircraft and relevant airworthiness standards to assess constraints on PPBE use, stowage, deployment, and design. They also studied proposed PPBE specifications. Several stowage and presentation concepts were developed and costed.

The next project in this series will study possible adaptations of a water spray for smoke suppression.

Contractor: Aviation Planning Services Ltd., Montreal, Quebec

Report: *(Draft)* Stowage and presentation of passenger protective breathing equipment, Aviation Planning Services Ltd., 1988

Schedule: October 1987 - June 1988

Funding:	TDC	$90 450
	Aviation Group	$15 000
		$105 450

Project Number: 6953
File Number: D 1455-162-2
Project Officer: Jean-Guy Richard

Emergency Locator Transmitters

Emergency locator transmitters (ELTs) have been in service in Canadian aircraft since 1974 and have helped save many lives. Yet numerous failures and false alarms have reduced the confidence of the aviation community in ELTs. Of approximately 700 ELT signals emitted each year in Canada, more than 90 percent are false alarms. About 60 percent of the ELTs involved in accidents fail to activate. The statistics are similar in the United States.

Clearly, better ELTs must be made available to aviators. Lives depend on search and rescue teams receiving accurate and immediate information on crashes. In the United States, the Federal Aviation Administration (FAA) has adopted minimum operational performance standards — FAA Technical Service Order C91a (TSO-C91a) — for ELTs made by new manufacturers.

In Canada, the use of ELTs by general aviation operators is regulated by Transport Canada. The urgent need for safer, more reliable ELTs has prompted Transport Canada's Aviation Group to form an ELT Working Group to address the problem. TDC is collaborating with this group on a number of projects.

In one project, researchers are assessing the short-term practicality of modifying existing ELTs to make them more reliable. An audio or visual signal to warn pilots of false alarms is being considered. Another project involves longer term research to evaluate new generation ELTs built to TSO-C91a specifications for Canadian use. In the first phase of this project, now underway, researchers are developing test procedures for the evaluations. Field trials and laboratory tests will follow. The results of this work will be used to make recommendations concerning the implementation of TSO-C91a in Canada.

Future work will address the development of a low cost, fly-away ELT for the general aviation market. A fly-away unit could detach itself from the aircraft so as to remain functional even though the aircraft may be destroyed by fire or explosion.

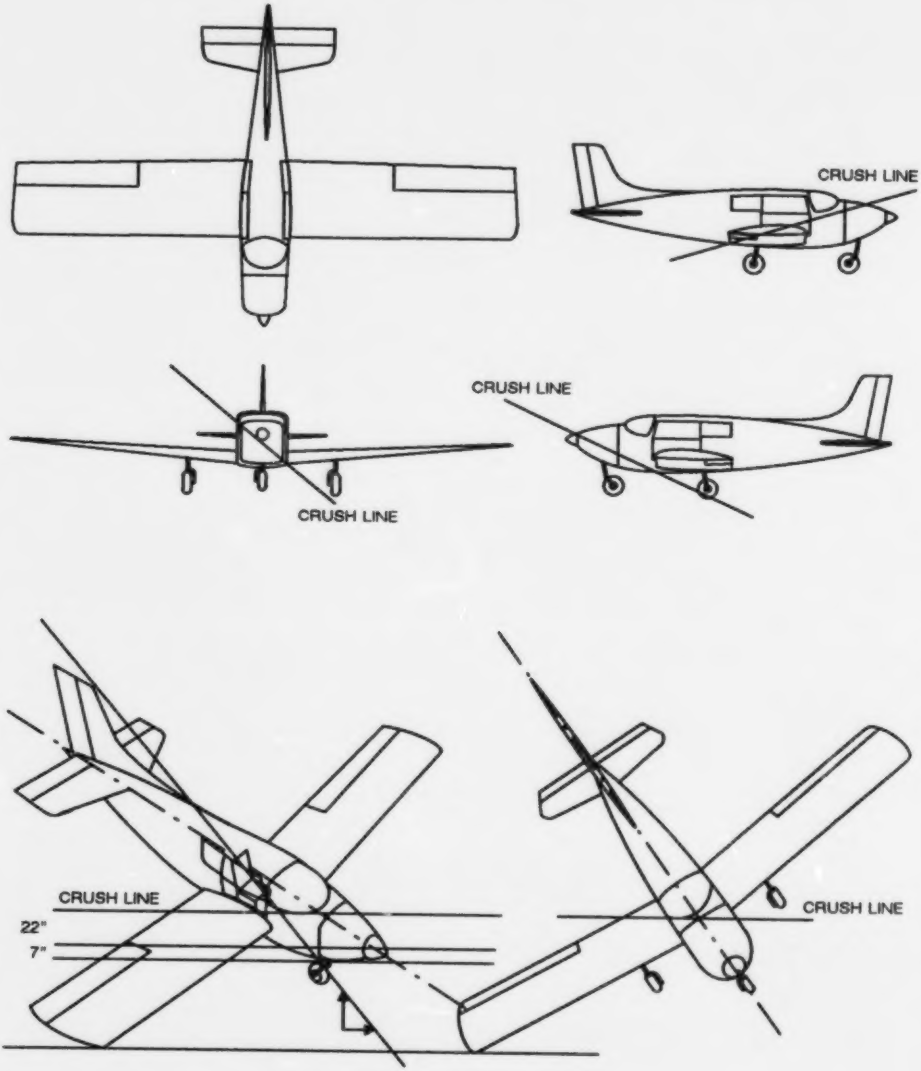
Contractors: Leigh Instruments Ltd., Ottawa, Ontario
DTI Telecom Inc., Montreal, Quebec

Report: None to date

ELT-100
ELS-10

New generation ELTs which conform to TSO-C91a, such as those shown, will be tested in operational trials.

Schedule: September 1987 - July 1988
Funding: TDC $189 944
Aviation Group $189 000
$378 944
Project Numbers: 6859/6995
File Number: D 1455-189
Project Officer: Howard Posluns


CRUSH LINE
CRUSH LINE
CRUSH LINE
CRUSH LINE
22"
7"
CRUSH LINE

Crashworthiness analysis: one technique used to establish the impact attitude of an airplane is analysis of the crush line. The crush line is formed as a result of the airframe being crushed against a surface, leaving a distinctive flat area in the airframe.

Small Aircraft Crashworthiness

Improving the ability of small aircraft to protect their occupants in crashes would save both lives and money. Statistics indicate that a program of improved crashworthiness could reduce costs to accident victims by 15 percent or four million dollars a year. This estimate is based on 1676 accidents occurring between 1976 and 1982 in Canada involving aircraft weighing less than 5680 kg. In 1979, small aircraft accounted for more than 90 percent of all aviation accident costs. Commercial operations of small aircraft accounted for almost 70 percent of all accident costs. The cost of achieving improved crashworthiness for small aircraft is unknown.

This project defined a research and development program for improving the crashworthiness of small aircraft. The researchers based their recommendations on a review of current research in Canada and the United States, and on data from accident investigations where crashworthiness was a factor. Among their recommendations were that a workshop be held and a further program of research be defined.

In March 1988 TDC and the Airworthiness Branch convened a seminar on small aircraft crashworthiness in Ottawa. It was well attended by representatives of government and industry from both the United States and Canada. The discussions at the seminar are being used by TDC, the Airworthiness Branch, and the National Research Council to help formulate a future program of research and development.

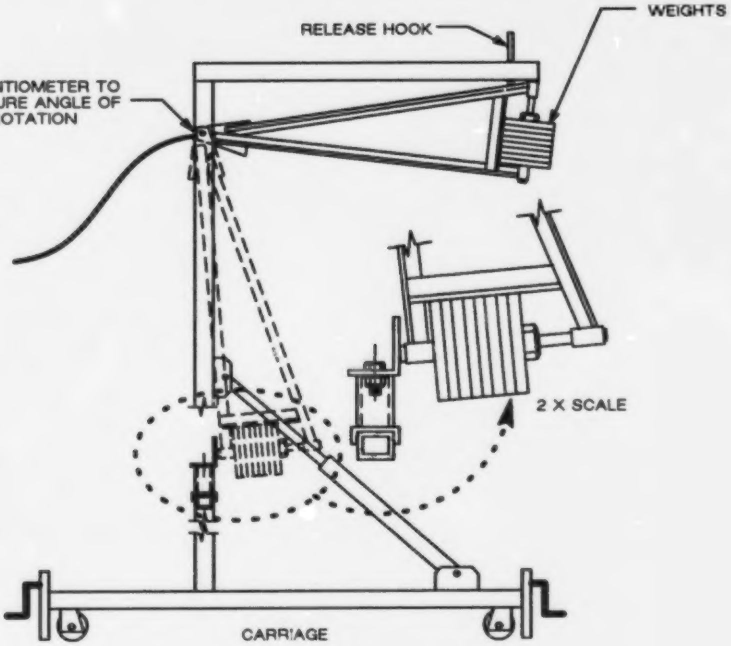
Contractor: Sypher:Mueller International Inc., Ottawa, Ontario

Report: TP 8655E, Small aircraft crashworthiness, Volumes 1 and 2, Sypher:Mueller International Inc., 1987

Schedule: September 1986 - March 1987

Funding:	TDC	$65 160
	Aviation Group	$10 000
		$75 160

Project Number: 6784
File Number: D 1455-183-1
Project Officer: W.S.C. McLaren


RELEASE HOOK
WEIGHTS
POTENTIOMETER TO MEASURE ANGLE OF ROTATION
2 X SCALE
CARRIAGE

Sketch of frangibility test rig

MLS antenna and support structure

MLS Support Structures

Aviation organizations around the world have recognized the safety benefits of using frangible structures for obstacles in the landing and take-off areas of airports. Transport Canada has required that such structures as the localizer antenna for the instrument landing system at airports be frangible. There are, however, no specifications for frangibility. The need for such specifications has become important as researchers develop a microwave landing system (MLS), which will become the primary aircraft landing system by 1998.

In previous work TDC supported the development of a microstrip antenna for the MLS. This project addressed the formulation of specifications for the frangibility of MLS structures. First, the contractor designed and built an MLS antenna enclosure and support structure with limited frangibility and subjected it to a series of tests. Researchers then developed frangibility concepts for three key design elements of MLS structures: connections, members, and mechanisms. They conducted impact tests on aluminum members bolted together to resemble connectors and on fibreglass-reinforced polyester members.

The test results indicate that the immediate needs for frangible MLS structures can be satisfied using low-mass, high-stiffness aluminum members connected with brittle aluminum fasteners. The report predicts that the ultimate frangible design may use fibre-reinforced plastic members with integral break points.

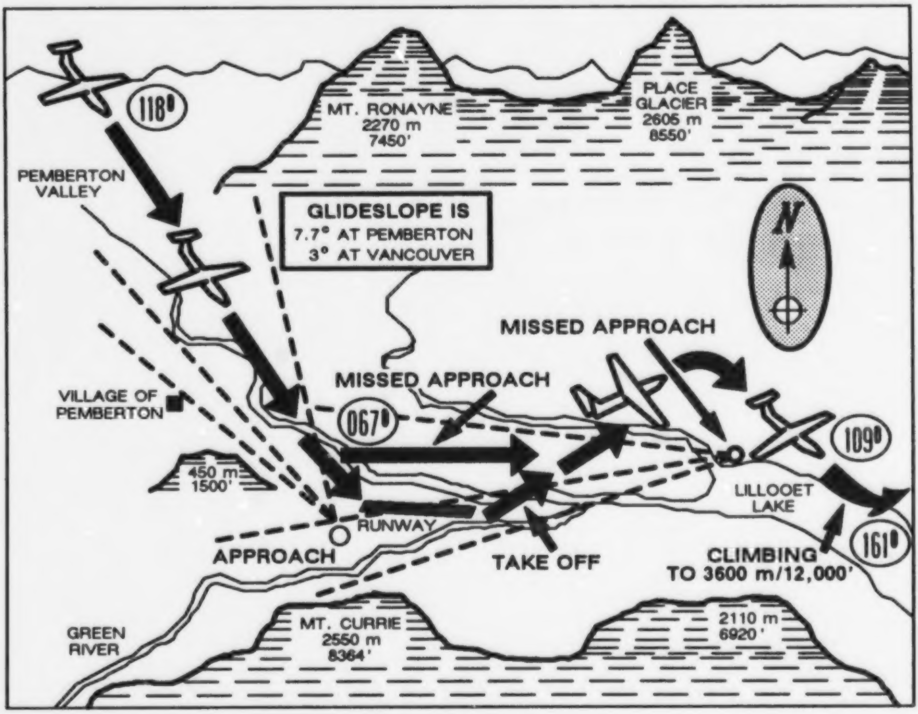
Contractor: Andrew Antenna Company Ltd., Whitby, Ontario

Report: TP 8478E, Frangible microwave landing system support structures, Andrew Antenna Company Ltd., 1987

Schedule: June 1986 - August 1987

Funding:	TDC	$64 000
	Aviation Group	$25 000
		$89 000

Project Number: 6729
File Number: D 1455-179
Project Officer: C. Alfred Versailles


118°
PEMBERTON VALLEY
MT. RONAYNE 2270 m 7450'
PLACE GLACIER 2605 m 8550'
GLIDESLOPE IS
7.7° AT PEMBERTON
3° AT VANCOUVER
N
MISSED APPROACH
MISSED APPROACH
VILLAGE OF PEMBERTON
067°
109°
450 m 1500'
LILLOOET LAKE
RUNWAY
APPROACH
TAKE OFF
CLIMBING TO 3600 m/12,000'
161°
GREEN RIVER
MT. CURRIE 2550 m 8364'
2110 m 6920'

MLS Installation at Pemberton

Approach and missed approach flight track and obstacle clearance planes

Pemberton MLS/STOL Assessment

Providing commercial air service in mountainous regions requires expert planning. TDC is supporting a project to investigate use of the microwave landing system (MLS) and short take-off and landing (STOL) DHC-7 aircraft technology for a difficult approach into a mountain valley site serving the Whistler resort area in British Columbia. Collaborating in the project are the Village of Pemberton, where the airport is located, Transport Canada's Pacific Region Aviation Group, Air B.C., de Havilland Aircraft of Canada Ltd., and Micronav Inc.

The approach flight path established for the airport is demanding. Aircraft must make a steep, 7.7° descent followed by a turn onto the runway. The missed approach procedure is even more demanding, requiring a turn at the missed approach point followed by a second, critical turn 6.4 nautical miles further down the valley. At present there are no standards in the world for such a procedure.

The service is being operationally tested and flight crews are being trained. Because of the unique operating environment and the new technology involved, all operational testing is being conducted under visual flight conditions until instrument flight rules have been demonstrated to be safe. The results of this work will provide guidelines for MLS/STOL approach procedures in mountainous regions elsewhere.

Commercial air service to Pemberton is expected to begin during the winter of 1988-89.

Contractor: Air B.C., Vancouver, British Columbia

Report: None to date

Schedule: March 1987 - March 1988

Funding:	
Supply and Services Canada	$198 000
TDC	$150 000
	$348 000

Project Number: 6857
File Number: D 1455-188
Project Officer: Barry B. Myers

MLS Signal Analyzer

The microwave landing system (MLS) will become the primary aircraft landing system by 1998, replacing the present International Civil Aviation Organization standard UHF/VHF instrument landing system.

The current method of testing landing systems, both for commissioning and certification, involves airborne tests using an aircraft equipped with special instruments. The procedure is expensive, can be conducted only under good flying conditions, and disturbs scheduled air traffic.

An earlier project developed and tested a prototype, first-article MLS antenna test facility, which included a guidance-angle simulator. This facility simplifies the testing and calibration procedures and significantly reduces the need for expensive airborne testing.

In this project researchers are modifying the facility and the simulator to solve problems identified in testing of the prototype. Modifications include frame timing synchronization, error compensation, turntable control, and various recording protocols.

Contractor: Canadian Astronautics Ltd., Ottawa, Ontario

Report: None to date

Testing of refinements to MLS signal analyzer

Schedule: September 1987 - August 1988
Funding: TDC $96 740
Project Number: 6869
File Number: D 1455-198-3
Project Officer: Micha Avni

Wind-Shear Detection Study

Wind shear — a sudden change in wind speed or direction — is a major threat to flight safety at several airports in the United States. Low-level wind shear has caused at least four major accidents in the U.S. over the past ten years, killing 401 people.

In Canada, wind shear is less severe owing to differences in geography and atmospheric conditions. While no Canadian accidents have been directly linked to wind shear, the phenomenon is suspected to have played a role in several accidents.

TDC and Transport Canada's Aviation Group are funding two parallel projects on wind shear. The objectives are to identify methods of detecting wind shear conditions around Canadian airports, methods of analyzing meteorological data, and ways of issuing warnings to aircraft.

Researchers determined user requirements for a wind-shear detection system, including the detection range and the response time required for advance warning. They are evaluating sensors capable of detecting wind shear, especially brief localized gusts of wind known as microbursts, and reviewing existing meteorological literature on the problem. A conceptual design for a warning system will be presented.

Transport Canada's Aviation Group, in collaboration with the National Research Council and the Canadian Aviation Safety Board, will evaluate the results of these studies to determine whether the costs and benefits of the proposed system warrant design and construction of a prototype.

Contractors: MacDonald Dettwiler & Associates Ltd., Ottawa, Ontario
Spar Aerospace Ltd., Ste-Anne-de-Bellevue, Quebec

Report: None to date

Typical wind shear situation

Schedule: August 1987 - September 1988

Funding:	Aviation Group	$85 000
	TDC	$45 000
		$130 000

Project Numbers: 6791, 6920
File Number: D 1455-186
Project Officer: Howard Posluns

Digital Voice and Data Logger Development

Air traffic control facilities log voice messages and data for use in investigating incidents and evaluating procedures. The logging systems now in service use analog recorders, which are mechanically complex and require daily maintenance. They also present serious operational problems: several channels are often combined on one recording track, producing unintelligible audio if more than one channel is active at a given time; and, access to the recorded data is cumbersome and time-consuming.

A digitized logging system would offer significant advantages: elimination of loss of intelligence due to superimposed channels, reduced maintenance costs, increased reliability and capacity, and increased accuracy of reconstructed data based on several data inputs.

TDC is supporting a project in collaboration with the Communications Systems Division of Transport Canada's Aviation Group to design, develop, and test a digital voice and data logging system.

The digital system will be capable of accepting a variety of information inputs including voice, data communications, and combinations of analog and digital signals. The data will be digitized, assembled into packets, sorted into files, and stored on a high-capacity optical disk. Flexibility to upgrade and reconfigure the system is being built into the design.

Modular design and programming flexibility will make the system attractive to many different types of organizations requiring precise data logging.

Researchers are completing the design of the system and bench-testing the components. Once the full system has been tested, it will undergo operational evaluation trials at a Transport Canada operational site.

Contractor: KOM Inc., Ottawa, Ontario

Report: None to date

Schedule: November 1987 - October 1988

Funding:	Supply and Services Canada	$123 000
	Aviation Group	$75 000
	TDC	$73 600
		$271 600

Project Number: 6956
File Number: D 1455-194
Project Officer: Howard Posluns

Knowledge-Based System for Resolution of Electromagnetic and Radio Frequency Interference

The proliferation and increased sophistication of radio equipment in and around airports promote an increase in electromagnetic and radio frequency interference (EMI/RFI). To prevent interference the source must first be identified; common sources include broadcast stations, navigational aids, and radar installations. Sources currently are located by Transport Canada specialists using documented flow-charts and test procedures. This is a highly skilled procedure, at times requiring the involvement of headquarters personnel. Developments in artificial intelligence technology suggested it would be possible to create a knowledge-based system to help identify and eliminate interference.

The objective of this project was to develop a knowledge-based system to identify, analyze, and resolve EMI/RFI problems related to the use of radio equipment in airports and air traffic control facilities. Researchers developed the knowledge base in collaboration with Transport Canada's EMI experts. The prototype system features various help menus to facilitate its use. There are two levels of complexity: the simpler involves following procedures and answering questions proposed on the screen; the more complex level presumes a familiarity with the software.

The system was appraised by Transport Canada personnel, and the contractor implemented changes based on their recommendations.

Contractor: CompEngServ Ltd., Ottawa, Ontario

Reports: TP 9126E, Development of a knowledge-based system for the resolution of electromagnetic interference, CompEngServ Ltd., 1988

TP 9132E, A knowledge-based system for the resolution of electromagnetic interference between radio systems: user's manual, CompEngServ Ltd., 1988

Schedule: March 1987 - March 1988

Funding:	Airports Authority Group	$40 000
	TDC	$25 800
		$65 800

Project Number: 6867
File Number: D 1455-190
Project Officer: Micha Avni

ATC Workstation

The Canadian Airspace Systems Plan provides a strategy for improving air traffic control (ATC) facilities and equipment to the year 2000. The plan shows how to accommodate changing demands for services, control costs, introduce new technologies, and deal with aging facilities. The plan argues that safety, capacity, productivity, and economy will be improved principally by introducing higher levels of automation, consolidating facilities and services, and applying new telecommunications technologies.

ATC workstations could benefit from a major upgrading in technology. The workstations receive flight plan information from pilots and dispatchers, and radar data from ground radar surveillance units. Some of these communication links are inefficient: flight information, for example, is passed by telephone and hand before it is entered on the ATC display screen. Human factor and engineering studies are needed to develop operational and technical specifications for a new workstation.

TDC, in collaboration with Transport Canada's Aviation Group, implemented a project to design, develop, and ergonomically evaluate a prototype ATC workstation. The findings from this work will be used to develop specifications. The workstation could also be used for human factors testing and evaluation of a variety of ATC interface configurations.

Researchers selected hardware capable of producing graphics in three dimensions. The hardware is compatible with that already operating at Transport Canada's Air Traffic Services (ATS) Research and Experimentation Centre in Hull, Quebec. Software was selected for organizing and measuring human performance issues, solid 3-D modelling, and computer-aided design. A prototype was installed at the ATS Centre and evaluated by a human factors specialist. Air traffic controllers were consulted about the console's operating features and ergonomic design.

The evaluations demonstrated that controllers could readily adapt to an electronic environment. The report recommends that the number of actions required of the air traffic controller must be reduced for both radar and flight data systems, but especially for the latter. Development of a highly automated flight data system could significantly improve the flight data rating of the prototype workstation. Further development of the workstation is continuing at the ATS Centre.

Contractor: The Arnott Design Group Inc., Toronto, Ontario

Report: TP 9218E, Development and evaluation of an ergonomically sound air traffic control workstation, The Arnott Design Group Inc., 1988

View of prototype workstation installed at the ATS Research and Experimentation Centre in Hull, Quebec

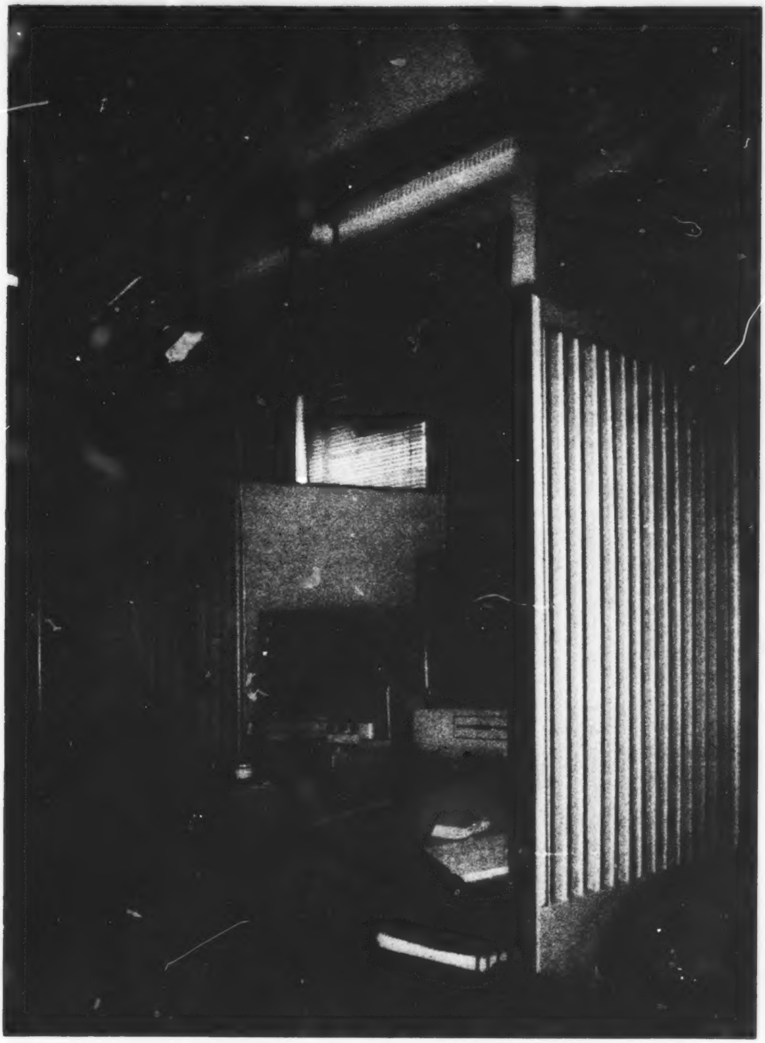
FLIGHT DATA
390
DL245
B727/A
2113
480
3431
UPDATE
INSERT
DELETE
OK
ABORT
BOS
BUF
J547
ECK
J94
J84
DPD

Detail of prototype radar display illustrating the use of the route editing feature to modify data from the radar position

Schedule: December 1985 - March 1988

Funding:	Supply and Services Canada	$400 000
	TDC	$200 000
	Aviation Group	$200 000
		$800 000

Project Number: 6583
File Number: D 1455-174
Project Officer: Roy S. Nishizaki



*Ergonomically designed workstation:
work surface is mauve, a neutral colour with low reflectance;
controls and handles are magenta, a bright colour for high visibility.*

Computer-Aided Learning for Air Traffic Control Electronics Technicians

Transport Canada is committed to modernizing air traffic control through the Canadian Airspace Systems Plan. Implementation of this plan requires special training for electronics technicians to keep them abreast of technological advances and to refresh their maintenance skills.

The goal of this project was to develop a comfortable, single-user, computer-aided learning workstation. Researchers conducted an ergonomic study of current standards for such factors as air quality, screen glare, and video display tube shielding. They also studied the relationship of body dimensions and sensory perception to workstations; motivation and the psychology of computer-aided learning; and, available input/output devices such as keyboard, mouse, character display, and audio unit.

The researchers developed and tested several layouts, then prepared design recommendations for the layout of the workstation and for typical training tasks that might be performed at the workstation.

The knowledge gained from this study can be applied in many areas where sophisticated electronic systems are used.

Contractor: Sypher:Mueller International Inc., Ottawa, Ontario

Reports: *(Draft)* Ergonomically designed workstation for training of electronic systems maintenance technicians, Volume 1: Literature review, Sypher:Mueller International Inc., 1988

(Draft) Ergonomically designed workstation for training electronic systems maintenance technicians, Volume 2: Baseline analysis, input devices, design recommendations, development of training workstation, Sypher:Mueller International Inc., 1988

Schedule: October 1985 - March 1988
Funding: TDC $194 936
Project Number: 6470
File Number: D 1455-166
Project Officer: Barry B. Myers

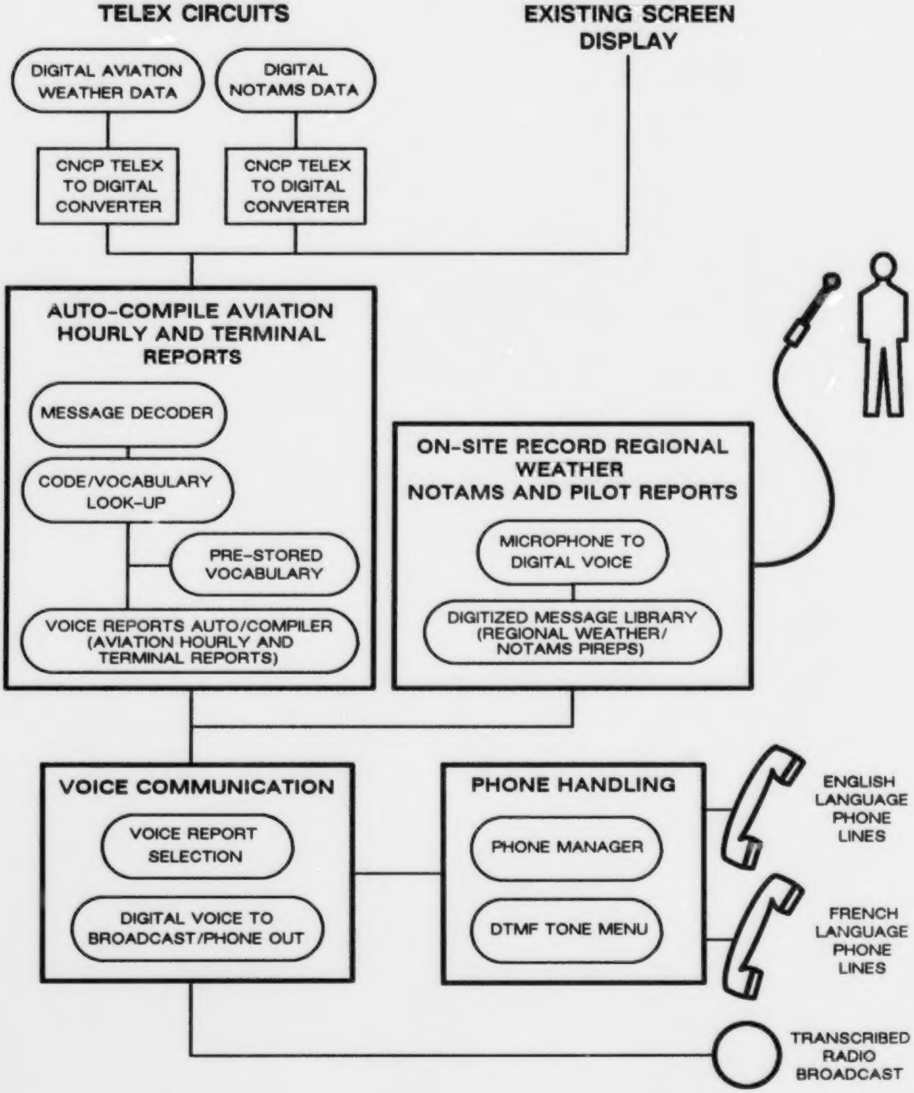

TELEX CIRCUITS
EXISTING SCREEN DISPLAY
DIGITAL AVIATION WEATHER DATA
DIGITAL NOTAMS DATA
CNCP TELEX TO DIGITAL CONVERTER
CNCP TELEX TO DIGITAL CONVERTER
AUTO-COMPILE AVIATION HOURLY AND TERMINAL REPORTS
MESSAGE DECODER
CODE/VOCABULARY LOOK-UP
PRE-STORED VOCABULARY
VOICE REPORTS AUTO/COMPILER (AVIATION HOURLY AND TERMINAL REPORTS)
ON-SITE RECORD REGIONAL WEATHER NOTAMS AND PILOT REPORTS
MICROPHONE TO DIGITAL VOICE
DIGITIZED MESSAGE LIBRARY (REGIONAL WEATHER/ NOTAMS PIREPS)
VOICE COMMUNICATION
VOICE REPORT SELECTION
DIGITAL VOICE TO BROADCAST/PHONE OUT
PHONE HANDLING
PHONE MANAGER
DTMF TONE MENU
ENGLISH LANGUAGE PHONE LINES
FRENCH LANGUAGE PHONE LINES
TRANSCRIBED RADIO BROADCAST

Diagram of aviation weather broadcast demonstration

Prototype Transcribed Weather Broadcast System

Transport Canada's Air Traffic Services (ATS) provides weather and special notices for aircraft flying at altitudes under 10 000 feet. Virtually all pilots of private aircraft use this service. ATS collects two sets of information: weather and notices to airmen (NOTAMS). These enter a preprogrammed microcomputer over two teletype circuits. Four types of weather information are provided in three categories: hourly and specials, terminal forecasts, and regional forecasts. Most of the information is unformatted: it contains an unlimited vocabulary and is presented in a nonstandardized format.

Currently, ATS personnel take the teletype reports, assemble them into standard ATS word format, and record them onto an audio tape. These recordings, known as a transcribed weather broadcast (TWB), are assembled and made available to pilots via telephone and radio. The recordings range from two to five minutes in length and are updated approximately every 30 minutes.

This project developed a prototype TWB system using teletype data translation that is capable of producing speech reports in French and English without operator assistance. The concept is based on an integrated transportation information system (ITIS), a recently demonstrated technology for a multimedia, interactive, transportation information system.

The prototype features adaptive and expert system concepts to process unformatted text input and software to emulate a multi-tasking system. The prototype is capable of dealing with unlimited vocabulary and splicing operator-created messages into computer-generated messages.

In November 1987 the prototype was installed at Vancouver International Airport for testing and evaluation. The testing is being conducted in two phases. The first phase tested the system off-line to verify its technical design; the current phase is being done on-line to evaluate user reaction. The prototype has functioned well in testing. The contractor is improving the system in collaboration with Air Traffic Services in Vancouver. Additional tests and evaluation of the enhanced system are planned for summer 1988.

Contractor: Oracle Communications Inc., Burnaby, British Columbia

Report: TP 9036E, Pilot weather information system, Oracle Communications Inc., 1987

Schedule: March 1987 - March 1988
Funding: TDC $69 400
Project Number: 6875
File Number: D 1455-191
Project Officer: John H. Morgan

Aeronautical Information: Computer Graphics Demonstration

Aircraft fly along predetermined flight paths from take-off to landing. These flight paths are prepared manually using topographical charts, templates, airport site plans, aeronautical information publications, and criteria such as tolerances.

The imminent introduction of new navigational aids such as microwave landing systems (MLS) will increase the number of flight paths and add new parameters to flight path design criteria. The new navigational aids also require a review of existing flight paths.

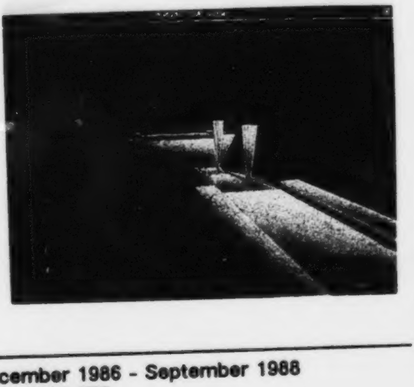
TDC, in collaboration with Transport Canada's Aeronautical Information Services (AIS), has commissioned a project to develop and demonstrate a computer graphics system for designing, modifying, and evaluating runway approach corridors using current criteria. The system must be capable of evaluating the criteria required for the next generation of navigational aids.

The pilot system includes terrain modelling and allows an unsophisticated user to interactively design a hypothetical instrument approach path in a three-dimensional environment. The high-resolution, graphic display can be rotated and translated. The system response time is fast enough to provide animated imagery.

The pilot system has been successfully evaluated in the Ottawa offices of AIS. Full system development is planned to start in late 1988.

Contractor: Virtual Prototypes Inc., Montreal, Quebec

Report: None to date



View of screen displaying elements of a runway approach path. The system permits modification and evaluation of various approach path configurations based on changing criteria.

Schedule: December 1986 - September 1988
Funding: TDC $283 975
Project Number: 6708
File Number: D 1455-177
Project Officer: Barry B. Myers

Calcium Magnesium Acetate for De-Icing at Airports

Canadian airports use the chemical urea to melt ice on runways and other airfield pavements. Another chemical, calcium magnesium acetate (CMA), is being considered as an alternative to urea. CMA has less environmental impact and is effective at lower temperatures. Transport Canada's Airports Authority Group is supporting this research into the use of CMA at airports.

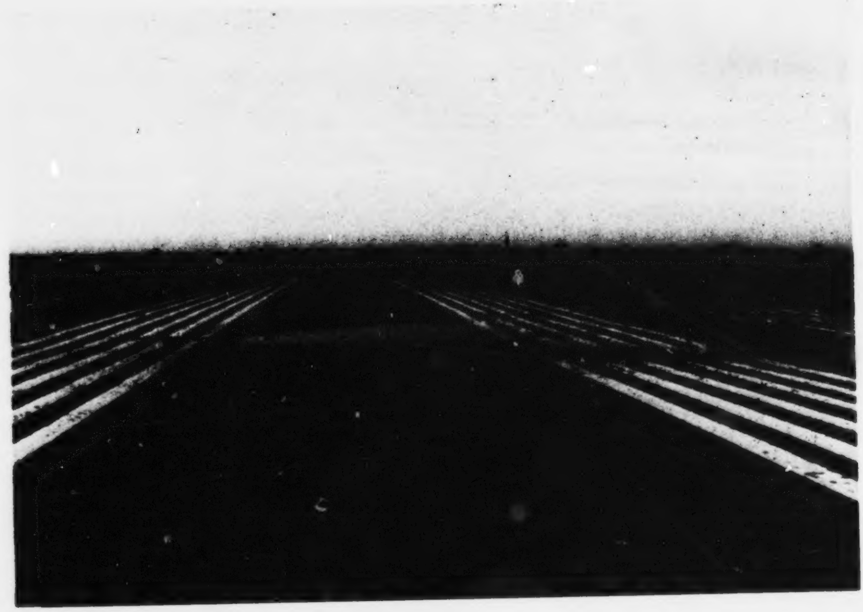
Many factors must be considered in choosing a de-icing agent. These include its effect on aircraft, on runway pavements, and on the environment. This project is aimed at defining a long-term research program into the economic and technical feasibility of using CMA at airports.

Researchers identified all areas that could be effected by the use of a de-icing agent in an airport environment, reviewed literature, and held consultations with informed persons to define the current status of CMA research. An analysis of the information gathered is underway to identify gaps in current knowledge that require more research before CMA could be introduced in airport operations.

Contractor: Sypher:Mueller International Inc., Ottawa, Ontario

Report: None to date

Schedule: March 1988 - September 1988
Funding: Airports Authority Group $44 450
Project Number: 6983
File Number: D 1455-195
Project Officer: Doug W. Dibble



Uneven surface of runway is highlighted by standing water.

Runway Surface Profile Roughness Analysis

Runway roughness affects the take-off and landing operations of jet aircraft. Roughness must also be considered in an airport's pavement management program.

Transport Canada measures the roughness of Canadian runways every year. It uses a variety of equipment, including profilometers and vehicle response meters to measure the degree, type, and location of runway roughness. The devices are calibrated annually against a Ride Comfort Index (RCI) developed for highways.

The measuring equipment and the measurement techniques have several limitations. Meter readings are subjective; calibrations change over time; the vehicle-based equipment, designed for highway use, measures short wavelength roughness only and cannot detect long wavelength roughness, which affects aircraft; and, there is no reliable way of comparing measurements with those taken by other pavement agencies and countries.

Ideally, it should be possible to measure runway roughness over a wide range of wavelengths by direct calculation from the longitudinal profile of a runway surface. Recent developments in high-speed, low-cost, profile data collection, combined with an existing computer-based analysis method, could produce a standard method for analyzing roughness from runway profile. The results could then be meaningfully shared among international aviation agencies in a manner similar to the International Roughness Index (IRI) currently used by highway and road research agencies around the world.

The objective of this project is to review and assess available methods for analyzing longitudinal runway profiles and evaluating roughness in order to determine the best method for Transport Canada.

Researchers are reviewing the literature and will evaluate measuring methods currently used. They will analyze data from ten runways, using several different methods, including the IRI and the current Transport Canada method. The results of this analysis will be used to recommend to Transport Canada the method best suited to its needs and any improvements that could be made in the method.

Contractor: John Emery Geotechnical Ltd., Downsview, Ontario

Report: None to date

Schedule: January 1988 - September 1988
Funding: Airports Authority Group $48 960
Project Number: 6999
File Number: D 1455-197
Project Officer: Doug W. Dibble

Aircraft Landing Patterns on Narrow Runways

Air transportation is the best access to most communities in the Canadian North. Many small airstrips exist and more are needed. Yet the cost of upgrading existing runways or building new ones is beyond the reach of most communities.

Transport Canada, which sets standards for runways, is committed to exploring cost-effective ways of improving the safety and efficiency of remote runways. Accordingly, TDC, in cooperation with airport and air regulatory authorities, is supporting a two-phase project to develop construction guidelines for safe, low-cost runways. The factor to be considered is runway width. If widths can be reduced without sacrificing safety, runway construction costs could be lowered.

In the first phase of the project researchers developed a method of measuring the landing behaviour of small aircraft. The method uses a video recording system to digitally record data on aircraft landings under a variety of crosswind conditions.

In the current phase of the project researchers are developing the video data recording system. After testing the equipment, data collection will begin. The data will be used to formulate recommendations to authorities on new standards for remote runway construction.

Contractor: R.S. Wallace & Associates Ltd., Manotick, Ontario

Report: None to date

Operational airstrip in Canadian hinterland

Schedule: January 1988 - September 1989

Funding:	Supply and Services Canada	$250 000
	TDC	$132 000
	Airports Authority Group	$45 000
	Aviation Group	$40 000
	Indian and Northern Affairs Canada	$20 000
	Yukon Government	$10 000
		$497 000

Project Number: 7007
File Number: D 1455-196
Project Officer: Barry B. Myers

Airport Pedestrian Flow Model

Pedestrian flow simulation models can play an important role in designing and operating airports. They can be used to design new or expanded facilities for optimum pedestrian flow. They can be used to explore alternative flow patterns in existing terminals, thereby increasing efficiency and level of service, improving airport response to peak overload conditions, and delaying or even eliminating the need for expansion.

In 1985 TDC initiated a project to develop a computer graphics program called Airport Graphics Display System (AGDS). The program would help airport planners and managers analyze pedestrian flow patterns by presenting data from a Traffic Flow Simulation Model (TFSM) in a more accessible pictorial form.

The usefulness of AGDS was clearly demonstrated, but it had a significant limitation: it was dependent on a mainframe TFSM to generate traffic flow estimates. A microcomputer TFSM was subsequently developed by Transport Canada's Airports Authority Group.

The purpose of the current project is to integrate the AGDS and the microcomputer TFSM as the final step in the development of a usable package for airport planners and managers. Researchers interviewed potential users at five major airports across Canada and then detailed the requirements for the integrated system. The existing modules are being modified to produce the optimum operational tool.

Contractor: IMC Consulting Group Inc., Edmonton, Alberta

Report: (*From previous work*) TP 7959E, Animated graphics simulation model for airport pedestrian flows, IMC Consulting Group Inc., 1986

Schedule: February 1988 - July 1988
Funding: TDC $86 100
Project Number: 7019
File Number: D 1455-172
Project Officer: Brian Marshall

Boarding Wheelchair Passengers at Small Airports

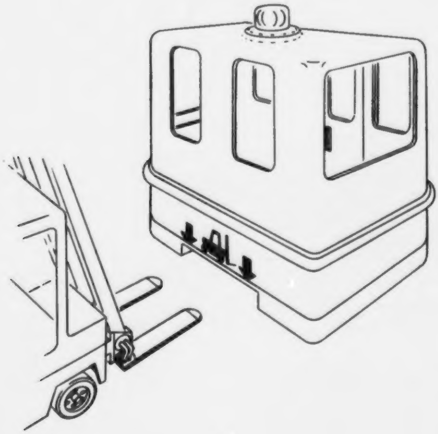
While Transport Canada's major airports are fully accessible to physically disabled persons, wheelchair passengers encounter great difficulty in boarding aircraft at smaller airports where there is no loading bridge from the terminal to the aircraft. The need for an effective boarding system for wheelchair passengers increases as the number of small aircraft serving smaller communities increases under regulatory reform and as mobility disabled and elderly persons travel in greater numbers.

Two recent TDC studies confirmed that access to aircraft is the single biggest obstacle for wheelchair travellers at smaller airports operated by Transport Canada. (Transport Canada operates 89 of the 153 federally owned airports in Canada.) An earlier project found that the boarding method most acceptable to the industry in the absence of a loading bridge is an enclosed pallet carried by a forklift truck.

In this project researchers will develop the pallet boarding device. It will be demonstrated and evaluated at a number of Transport Canada airports over a twelve-month period.

Contractor: Not yet identified

Report: None to date



Conceptual design of pallet boarding system

Schedule: June 1988 - January 1990
Funding: TDC $150 000
Project Number: 7014
File Number: D 1450-103-37-3
Project Officer: Roy S. Nishizaki

Small Aircraft Accessibility for Wheelchair Passengers

The Domestic Service Air Standards Task Force of Transport Canada's Domestic Air Policy branch is establishing standards of accessibility for aircraft with 60 or more passenger seats used in domestic scheduled service. Little attention, however, has been given to aircraft with fewer than 60 seats. As the number of commuter, regional, and feeder airlines increases in Canada, wheelchair access to small aircraft is becoming a pressing issue.

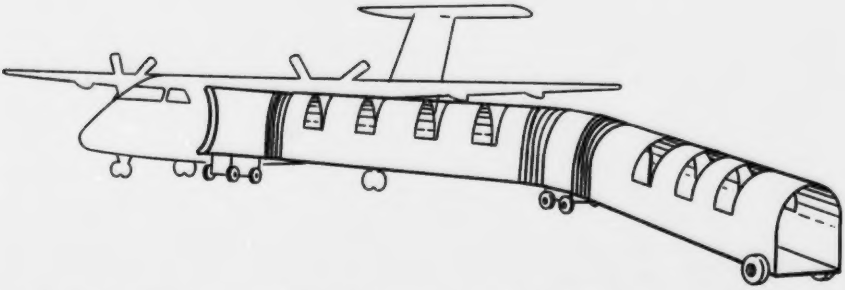
The objective of this project is to investigate technical solutions to the problem of boarding, seating, and deboarding wheelchair passengers on small aircraft.

Researchers are studying the design constraints and storage capacities of various small aircraft. They will determine whether existing boarding devices used for larger aircraft can be adapted to small aircraft.

The results of this work could identify a technical solution for improving small aircraft accessibility for wheelchair travellers that meets the requirements of both the passengers and the operators.

Contractor: James F. Hickling Management Consultants Ltd., Ottawa, Ontario

Report: None to date



Concept of loading bridge adapted for use with commuter aircraft

Schedule: November 1987 - October 1988
Funding: TDPP $46 000
Project Number: 6967
File Number: D 1450-103-83
Project Officer: Barbara A. Smith

In-Cabin Storage of Wheelchairs

Air carriers are responding to the needs of disabled travellers by providing special equipment, facilities, and services. Problems remain, however, in the transport of wheelchairs. They are difficult for baggage personnel and attendants to handle, and they are often damaged when stored in aircraft cargo holds.

Several years ago TDC supported a series of projects to find a technical solution to these problems. These projects focussed on developing a container to protect a wheelchair during flight. A container was developed but it has not found widespread acceptance because of the cost to carriers and the logistics of its use.

The objective of this project was to examine the possibility of storing wheelchairs and scooters in the passenger cabin. If feasible, this method of accommodating wheelchair travellers could reduce handling costs, reduce the incidence of damage to chairs and scooters, and allow travellers to use their personal equipment in boarding.

Researchers examined airworthiness and safety regulations, current carrier handling procedures, and available in-cabin storage areas in various types of aircraft. They concluded that although it was not feasible to store battery-operated scooters in the passenger cabin, it was feasible to store folded manual wheelchairs in a cabin unit designated for carry-on baggage. However, not all aircraft have this unit and, if they do, its allocation is at the discretion of the individual carrier.

The results of this project are being reviewed by Transport Canada's Domestic Service Air Standards Task Force, which is responsible for the development of air accessibility standards for aircraft with 60 or more passenger seats.

Contractor: W.R. Davis Engineering Ltd., Ottawa, Ontario

Report: TP 9033E, Feasibility study of in-cabin storage of wheelchairs and scooters on commercial aircraft, W.R. Davis Engineering Ltd., 1988

Schedule: November 1986 - April 1988
Funding: TDPP $24 000
Project Number: 6716
File Number: D 1450-103-78
Project Officer: Barbara A. Smith

Communicaid II

In 1984 TDC supported a project to design a system of integrated communication aids for persons with sight, speech, or hearing impairments. Suitable state-of-the-art communications systems were integrated into a single system suited to the needs of travellers and carrier agents in transportation terminals. The system, Communicaid, was evaluated in service at Vancouver International Airport from May 1986 to March 1987.

The system provided communication-impaired travellers with information on arrivals and departures and on the location of terminal services. But the system had several shortcomings: some travellers were intimidated by its screens and controls; there was no eye-level screen to accommodate the visually impaired traveller; and communication-impaired travellers wishing to alter or make bookings required the help of an attendant.

The objective of this project is to develop a second-generation Communicaid offering better service than its predecessor. Multiple screens and complex controls are being replaced with a single, touch screen and the 'Dialog' mode will be removed to facilitate unattended operation. *(See also page 110.)*

Communicaid II will be evaluated in service at Vancouver International Airport.

Contractor: Rutenberg Design Inc., Lachine, Quebec

Report: None to date

Mock-up of Communicaid II. Features include adjustable touch screen and fold-away seats.

Schedule: July 1987 - November 1988
Funding: TDPP $140 000
Project Number: 6908
File Number: D 1450-103-44
Project Officer: John H. Morgan

Portable Communicator/Translator

Transportation terminals are frequently stressful places for travellers. Carriers have to process many passengers in the shortest possible time in order to maintain competitive schedules. This results in long queues and short tempers. The stress is even greater for travellers who have hearing or speech impairments, or who cannot speak English or French. Technology may hold a solution to the problems faced by these travellers.

The objective of this project is to develop and construct a portable device to help communication-impaired travellers communicate with carrier representatives. Researchers will build on experience with Communicaid, an integrated system of communication aids for persons with sight, speech, or hearing impairments that was evaluated in service at Vancouver International Airport in 1986-87.

The new device presents a touch screen and speaker to both the traveller and the agent. It has a limited memory of words and phrases commonly encountered at transportation terminals; the words are available through menu selection. Questions and answers can be formulated in either English or French, but are presented in both languages. Translation in Spanish and Chinese will be available for the demonstration to evaluate the multilingual features of the system: the traveller's screen will present the language he or she has selected, while the agent's screen continues to present French and English.

The possibility of using menus that are not limited to yes/no answers is being studied through a series of tests with prospective users. A prototype will be built and tested. Evaluations will be conducted at the international airports in Vancouver and Dorval (Montreal).

Contractor: Rutenberg Design Inc., Lachine, Quebec

Report: None to date

Schedule: September 1987 - August 1988

Funding:	TDPP	$44 169
	Airports Authority Group	$30 000
		$74 169

Project Number: 6912
File Number: D 1450-103-44-4
Project Officer: John H. Morgan

MARINE TECHNOLOGY

MARINE TECHNOLOGY

Canada's marine environment, comprising three oceans and an extensive inland waterway, poses numerous research and development challenges. The underlying focus of TDC's marine technology R&D program is the design, regulation, and safe operation of vessels in all Canadian waters. The program currently emphasizes: developing technologies applicable to marine transportation in Arctic waters and technologies aimed at making shipping safer; supporting Transport Canada's role in search and rescue; and, supporting the Canadian Coast Guard (CCG) in improving its operational efficiency through the application of new technology.

Ice-Transiting Vessels: Performance and Technology

R&D in this section relates directly to the design of ships destined for operation in ice-covered waters. Research is aimed at:

- providing a scientific basis for design criteria applied to ships navigating in Arctic waters and for the regulation of Arctic shipping;
- developing a knowledge base of mathematic and scale modelling techniques for predicting the performance of ships in ice; and,
- fostering the development of improved ship technologies to allow safe, efficient marine transport of resources in the Arctic while protecting the environment.

Ice Navigation and Precision Navigation in Confined Waters

Problems of navigation in ice-covered Arctic waters are unique to Canada. It is important to develop efficient icebreaking technology; however, in heavy Arctic ice, the best navigation strategy is to select the easiest path through the ice field. This strategy requires sophisticated electronic ice-sensing technology. Over the past 15 years, TDC has been working with Canadian industry to develop an advanced ice-navigation system. Canada now leads the world in this technology.

The initial work was directed towards navigation systems for commercial ships. The MV *Arctic* served as a test bed for new technology evaluations. The technology is now being applied onboard CCG vessels. Current work is aimed at providing the CCG with an independent, helicopter-mounted, ice-reconnaisance capability.

Inland and coastal shipping could benefit from accurate, all-weather, vessel-positioning systems to enable safe operations in narrow channels, coastal waters, and densely populated shipping lanes. Mariners are faced with an increasing amount of complex navigational information from various sensors. At present there is no system for gathering, integrating, and consistently displaying this information to make it more useful to mariners in solving navigation problems. TDC is currently supporting two precision navigation projects, one aimed at improving the presentation of navigational data to navigators and the other aimed at improving radar identification of areas presenting poor natural radar reflection.

Safety

TDC is committed to increasing the safety of government and commercial vessels operating in Canada's southern waters. To this end TDC is pursuing several safety-related projects including: studying the effect of ice loads on fishing vessels; testing de-icing techniques for use on small vessels; and, classifying wind and wave conditions on the Great Lakes, the St. Lawrence River, and Atlantic coastal waters for reference by ship designers.

Effective deployment of the Canadian Coast Guard's search and rescue facilities requires sophisticated technologies to detect, identify, and monitor small objects at sea. Improved search and rescue technology is particularly important in view of the increasing offshore activity. Growth in fishing fleets and petroleum exploration has added to the proliferation of vessels and structures at sea. A major project in this section addresses the detection of small objects at sea.

General Marine Research

TDC is involved with several general marine technology projects. In support of tug and barge transportation widely used by forestry and other resource-based industries in British Columbia, TDC is pursuing projects to develop more energy-efficient tug and barge combinations.

TDC is fostering the development of standards for the use of fibre-optic technology onboard civilian marine vessels. Past studies by TDC concluded that fibre-optic technology could facilitate engine room automation and remote control in the electrically noisy and harsh physical environment of a ship. Ship automation has been identified as an important new thrust for TDC's R&D activities.

Ice Loads on Propeller Blades

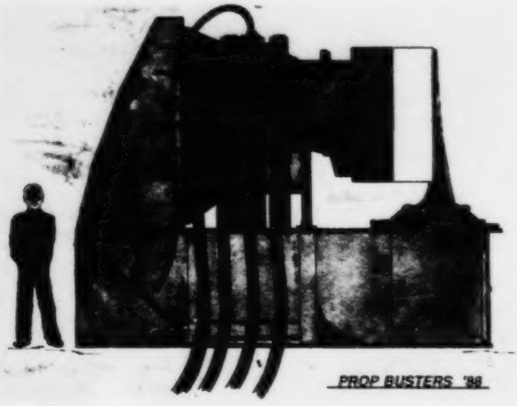
Ships operating in ice often damage their propeller blades. The Canadian Coast Guard vessel *Martha L. Black* recently lost three blades during astern manoeuvres in ice. Better understanding of the process leading to propeller blade damage is necessary in order to develop design or operational guidelines that could prevent the damage and the attendant risk to crews and ships.

In this project researchers are measuring the response of a propeller blade to ice loads in order to better understand how propellers interact with ice.The work is being done on a specially built test rig. Sensors and other instruments have been mounted on an ice-strengthened bronze propeller blade. The blade is mounted on a test rig that can rotate the blade 360° about its axis, providing different interactions with an ice block. Loads of up to two newton metres can be applied near the blade's tip.

Researchers are conducting a series of tests by ramming the blade into hard fresh-water ice, while recording force, pressure, and reaction. Tests may also be conducted in which the blade is permanently deformed. The researchers are obtaining data about: pressure distribution across the blade face; behaviour of the blade about the yield point; blade strain and deformation; and, global ice force during ice/blade interaction.

Contractor: Geotechnical Resources Ltd., Calgary, Alberta

Report: None to date



Propeller blade test rig. The reaction frame is capable of withstanding a 2 N•m load applied near the blade tip.

Schedule: October 1987 - December 1988
Funding: TDC $218 000
Project Number: 6976
File Number: D 1460-254
Project Officer: Pierre L. Semery

Shrouded Propellers: Investigation of Ice Flow and Blockage

The propellers on many icebreaking ships are protected from ice damage by a shroud, or nozzle. Nozzles also enable the propellers to produce more thrust in water and reduce cavitation. However, as icebreaking ships have become more capable, many have experienced serious operational limitations from what is believed to be caused by nozzle/ice interaction. Recent tests on the icebreaking tug/supply ships *Canmar Kigoriak* and *Robert Lemeur* show that torque and thrust vary significantly as ice interacts with the nozzle. As well, nozzles sometimes become clogged with pieces of ice, forcing the ship to reverse direction in order to dislodge ice.

The objectives of this project are: to study the flow of ice through a nozzle; to understand how ice in a nozzle affects the propeller's torque and thrust; and, to find ways to reduce ice blockage in nozzles.

The test plan for the project was developed through analysis of full-scale and model data for the *Canmar Kigoriak* and the *Robert Lemeur*, and from the literature on nozzles. Research for this project is being conducted on a 1:15 scale model of the Canadian Coast Guard ship *Louis S. St. Laurent*, suitably instrumented and calibrated and with a nozzle fitted to the centre propeller.

The results of this work will provide a better insight into the mechanism of the blockage phenomenon so that nozzle modifications aimed at reducing the problem may be evaluated.

Contractor: Arctic Research and Development Ltd., Bragg Creek, Alberta

Sub-contractors: Institute for Marine Dynamics, St. John's, Newfoundland
NORDCO Ltd., St. John's, Newfoundland

Report: None to date

Schedule: July 1987 - December 1988

Funding:	EMR - Energy R&D Program	$142 079
	CCG	$70 000
	Supply and Services Canada	$67 000
		$279 079

Project Number: 6948
File Number: D 1460-251
Project Officer: Pierre L. Semery

Ship Propulsion/Ice Interaction: *Jarvsaar* Tests

Limited, full-scale test data on the performance of ship propulsion trains in ice are available to designers, regulators, and ship owners. It is important to update and verify the data base whenever possible.

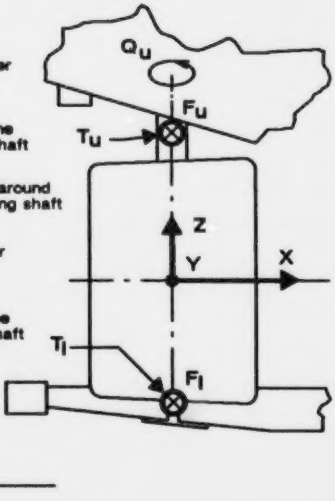
This project compared data obtained from full-scale testing of the Finnish trawler *Jarvsaar* with the data and analytical modelling work on propellers and nozzles carried out by Canadian Marine Drilling Ltd. using the icebreaking tug/supply ship *Robert Lemeur*.

The *Jarvsaar* is similar to a Class 1 ship as defined by Canadian Arctic Pollution Prevention Regulations. The vessel was tested with an open and a shrouded propeller in winter ice in the Baltic Sea. The interaction of the propeller with the ice was recorded by an underwater video camera.

The comparison confirmed the validity of several elements of existing ice/propeller interaction models. It also revealed areas where additional research is needed. For example, additional data on the effect of ice wedging between the hull and the nozzle are needed. This interaction is not accounted for in existing models.

Contractor: Valmet Arctic Canada Ltd., Calgary, Alberta

Report: *(Draft)* Ship propulsion/ice interaction study: *Robert Lemeur* versus *Jarvsaar* comparison, Valmet Arctic Canada Ltd., 1988


T_u Thrust of the upper attaching shaft
F_u Lateral force of the upper attaching shaft
Q_u Turning moment around the upper attaching shaft
T_l Thrust of the lower attaching shaft
F_l Lateral force of the lower attaching shaft
Q_u
F_u
T_u
Z
Y
X
T_l
F_l

Schematic of instrument locations on the Jarvsaar.

Schedule: January 1987 - February 1988
Funding: TDC $69 700
Project Number: 6783
File Number: D 1460-244
Project Officer: Ian M. Bayly

Ice Class Ships: Added Mass Studies

Researchers need to better understand how the structural loading on an icebreaking ship during ramming is affected by its added mass. (Added mass is the mass of the water surrounding the vessel that accelerates with the vessel.) Existing studies of added mass are based on ship operations in open water and do not apply to vessels in ice. Some exploratory work in the field has been done by Fleet Technology Ltd. (formerly Arctec Canada Ltd.), using data from trials with the cargo icebreaker MV *Arctic*. However, more analysis is needed to refine modelling techniques to accurately reflect the effects of added mass.

TDC supported two added mass studies. The first investigated the effect of the added mass phenomenon on ship/ice interaction using the results of earlier global load testing with a flexible model of the MV *Arctic*. Researchers identified methods for isolating hydrodynamic forces in hull response prediction models. They also developed a semi-empirical data base of hydrodynamic added mass and damping applicable to longitudinal vertical plane response of the MV *Arctic* hull form.

The second study developed a three-dimensional, finite element model of the water to evaluate the added mass of a ship ramming various thicknesses of ice. The model predicts the added mass of any ship with arbitrary definition of the boundaries representing the bottom and ice proximities, ice thickness and geometry, and hull shape.

Neither study produced a sufficiently general methodology for dealing effectively with ship response predictors and analyses. TDC has subsequently commissioned Coldstream Maritime Inc. to conduct an in-depth review of the results of both studies. This review is now underway.

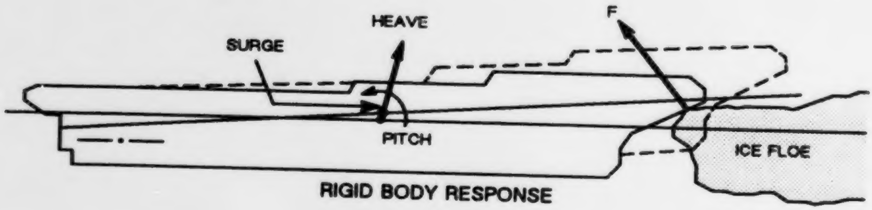
Contractors: Det norske Veritas Ltd., Calgary, Alberta

Fleet Technology Ltd. (formerly Arctec Canada Ltd.), Kanata, Ontario

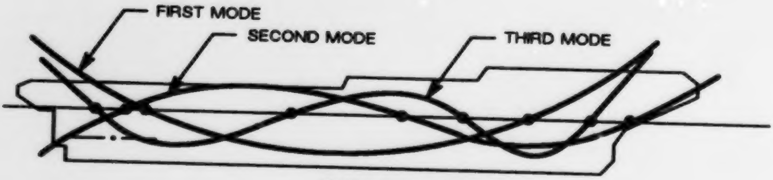
Reports: TP 8392E, Development of an analytical model of the hydrodynamic added mass of a ship ramming ice, Det norske Veritas Ltd., 1987

TP 8393E, Development of an analytical model of the hydrodynamic added mass of a ship ramming ice, summary report, Det norske Veritas Ltd., 1987

TP 8797E, Investigation of hydrodynamic added mass with a flexible model of the MV *Arctic* (three volumes), Fleet Technology Ltd., 1987


HEAVE
F
SURGE
PITCH
ICE FLOE

RIGID BODY RESPONSE


FIRST MODE
SECOND MODE
THIRD MODE

FLEXURAL RESPONSE

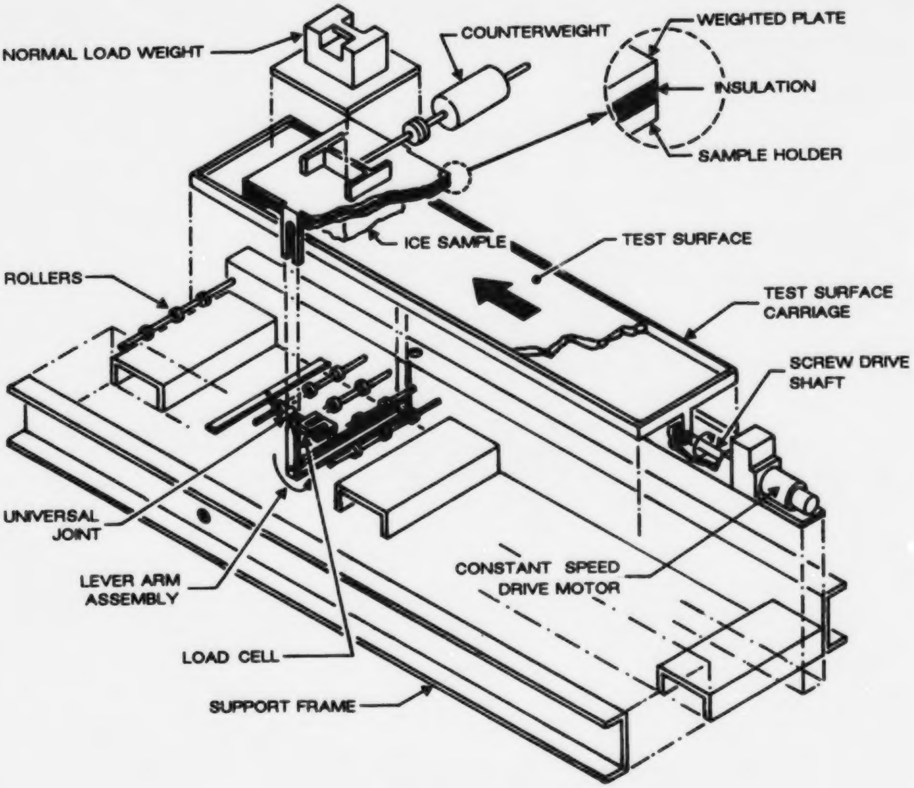
Rigid body and vibration modes investigated

Schedule: May 1986 - March 1987

Funding:

CCG	$146 000
Supply and Services Canada	$141 000
TDC	$135 000
	$422 000

Project Numbers: 6633, 6637
File Numbers: D 1460-231/2
Project Officers: Neil R. Gore, Ian M. Bayly, C. Nowicki


NORMAL LOAD WEIGHT
COUNTERWEIGHT
WEIGHTED PLATE
INSULATION
SAMPLE HOLDER
ICE SAMPLE
TEST SURFACE
ROLLERS
TEST SURFACE CARRIAGE
SCREW DRIVE SHAFT
UNIVERSAL JOINT
LEVER ARM ASSEMBLY
CONSTANT SPEED DRIVE MOTOR
LOAD CELL
SUPPORT FRAME

Schematic of jig used to measure ice/hull friction

Ice/Hull Friction Coefficient

Model tests of an R-Class (River Class) icebreaker and the heavy icebreaking cargo carrier MV *Arctic* have not produced accurate predictions of the full-scale vessels at sea. Researchers attribute the poor correlations in the case of the MV *Arctic* to differences between model ice and sea ice properties, hydrodynamic characteristics of test tanks, and erroneous friction coefficients.

This project addresses the problem of friction coefficients. Researchers want to establish a reliable correlation between the friction coefficients of models and of full-scale vessels.

Previously, full-scale friction coefficients were obtained by testing small areas of the hull using sledges and flat plates. Researchers now realize that this method does not produce an accurate measure of the actual conditions experienced by a ship's complete hull during icebreaking. The problem was identified through experiments aboard the German research vessel *Polarstern* that analyzed information from a triaxial load cell sensor mounted on the ship's hull. The data from these experiments have been made available to TDC.

In this project, reseachers compared the data from the *Polarstern* full-scale tests with model tests of the MV *Arctic*. They found a number of factors that influence friction coefficients. For example, tests demonstrated that the friction coefficient is dependent on the normal force, the type and roughness of the surface of the hull, and on the type and condition of the ice. Its effect was found to be significantly stronger at the bow than at the mid-body.

Contractor: Melville Shipping Ltd., Ottawa, Ontario

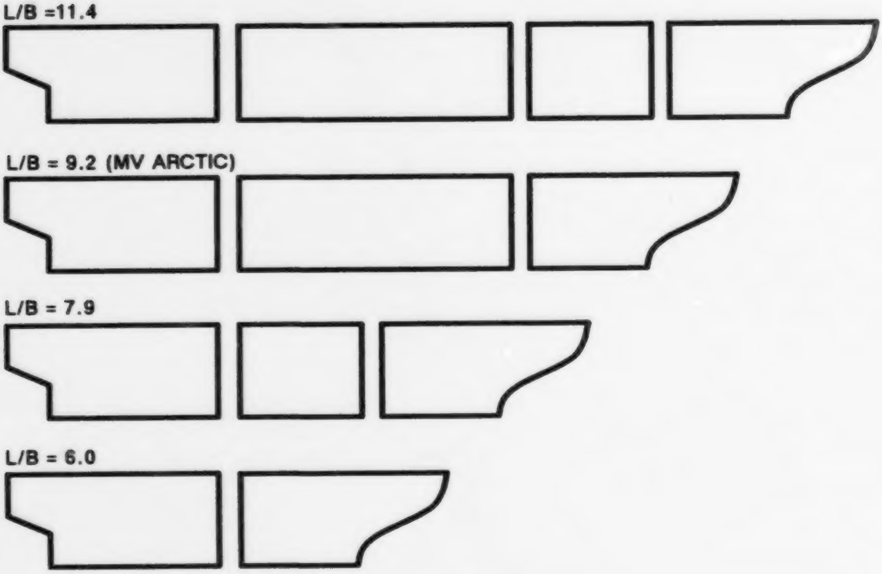
Reports: TP 8915E, Ice/hull friction coefficient study, Melville Shipping Ltd., 1988

TP 9013E, Ice/hull friction coefficient study, summary report, Melville Shipping Ltd., 1988

Schedule: July 1986 - March 1988

Funding:	Supply and Services Canada	$67 000
	TDC	$62 500
	CCG	$15 000
		$144 500

Project Number: 6709
File Number: D 1460-235
Project Officer: Roy S. Nishizaki


L/B =11.4
L/B = 9.2 (MV ARCTIC)
L/B = 7.9
L/B = 6.0

Sketch of model segments, based on the MV Arctic, used to assess the influence of parallel midbody on ship performance in level ice

Icebreaker Midbody Resistance

The resistance of a ship's hull to icebreaking has traditionally been determined by studying models of specific ships. The resistance has been calculated as a composite without identifying the contributions to total resistance made by specific dimensions of the hull form. Better understanding of uni-dimensional resistance, particularly with respect to length and beam effects, could contribute to better icebreaker design.

The objective of this project was to determine how variations in midbody length, length/breadth ratio, bow shape, and friction affect icebreaking resistance.

Researchers used an existing 1:30 scale sectional model of the icebreaking cargo carrier MV *Arctic* to obtain four different lengths of parallel midbody. Bow shape and friction were studied through model variations using the old and new bow shapes of the MV *Arctic* and three bow friction coefficients.

The researchers concluded that the influence of midbody length on resistance varies with bow form, the model's speed, and the ice thickness. The precise nature of this dependency is not fully understood. The friction coefficient test revealed higher speed dependency for certain configurations than was anticipated; more research is needed to understand the impact of vessel speed on resistance. However, the researchers developed an ice thickness correction factor to account for ice thickness variations at model and full scale.

The test program proved the usefulness of the ice strength indexer developed in a previous TDC project. Researchers were able to continuously monitor ice sheet strength.

Contractor: Melville Shipping Ltd., Ottawa, Ontario

Report: *(Draft)* Effect of parallel midbody on the resistance of ships in level ice, Melville Shipping Ltd., 1988

Schedule: October 1987 - April 1988

Funding:	**TDC**	**$85 000**
	Supply and Services Canada	**$50 000**
	National Research Council Canada	**$35 000**
		$170 000

Project Number: 6971
File Number: D 1460-255
Project Officer: Thomas Peirce

Propulsion Dynamics Mathematical Model

A ship's propulsion train — its propeller shaft, stern bearing, and propeller — must be strong enough for its operating environment. Icebreakers in particular require sturdy propulsion components. Over the past few years a great quantity of data has been collected about the interaction of propulsion trains and ice. A computer model incorporating this data would be a valuable tool for designing propulsion trains for icebreakers and other ships operating in ice. It could also be used to evaluate a ship's compliance with Arctic shipping regulations.

The objectives of this project are to develop the model, to use the model to evaluate existing designs and regulations for propulsion trains, and to identify manoeuvres or operating conditions that may overload propulsion components.

Researchers have developed a numerical computer model based on data gathered from full-scale trials of the MV *Kalvik*, MV *Robert Lemeur*, MV *Arctic*, CCGS *Pierre Radisson*, CCGS *Louis S. St. Laurent*, and USCGS *Polar Sea*. The model applies to any class of vessel similar to these vessels. The model's parameters include shafting response, machinery signals, rudder stock torque, bearing loads, and hull flexibility. The model structure, implemented to run on an IBM PC/AT, and solution techniques are being tested.

Contractor: Fleet Technology Ltd. (formerly Arctec Canada Ltd.), Kanata, Ontario

Report: None to date

Schedule: September 1987 - September 1988

Funding:	TDC	$163 000
	EMR – Energy R&D Program	$100 000
		$263 000

Project Number: 6947
File Number: D 1460-241
Project Officer: Pierre L. Semery

Ice Resistance Simulation

Theoretical models exist which describe the mechanisms involved in icebreaking. However, these models cannot accurately indicate the relative contribution of each mechanism to the total ice resistance force, nor can they support the methods used for full-scale prediction. Application of the Distinct Element Method (DEM) to the study of ice fracture mechanics could improve modelling.

The objective of this project is to adapt and apply the DEM to ship/ice resistance by modelling ice stresses, deformation, failure modes, breaking patterns, and subsequent paths of the broken ice, including interaction forces on the icebreaking hull. The results should provide an improved quantitative understanding of the several mechanisms and processes contributing to icebreaking forces and resistance.

The work is being carried out in two phases. In the first phase, researchers are reviewing existing methods of simulating and calculating ice interaction with icebreaking ships. Then they will adapt and demonstrate the effectiveness of the DEM for ship/icebreaking applications. The report of this work will be reviewed and assessed before the second phase of the project is commissioned.

In the second phase, researchers will conduct a detailed numerical parametric study to provide data for design and regulatory work.

Contractor: Offshore Mechanics Ltd., St. John's, Newfoundland

Report: None to date

Schedule: December 1987 - December 1988

Funding:	TDC	$57 000
	Supply and Services Canada	$50 000
		$107 000

Project Number: 6965
File Number: D 1460-253
Project Officer: Ian M. Bayly

Icebreaker Design Synthesis

Shipping companies operating in the Arctic have prompted significant research in icebreaking technology during the past decade. In particular several icebreakers operating in the Beaufort Sea embody radical departures from earlier designs. Performance data on the Beaufort Sea vessels are now available for study and personnel familiar with the design and operation of the vessels are available for consultation.

The objective of this project is to document and analyze the knowledge embodied in new commercial icebreakers, especially the Beaufort Sea vessels, and blend it with the data available from Canadian Coast Guard vessels. This data base of Canadian icebreaking expertise would then be made available to researchers and designers.

Researchers will study eight hull shapes, three propulsion systems, and four auxiliary icebreaking devices. They will also document the operating experiences of the crews.

The researchers have developed a classification system for ship performance categories which includes elements of mission profiles related to the icebreaking function. Categories and design features are being set into a matrix to indicate how contemporary design features affect performance. The researchers will develop theoretical models for designs using equations derived from basic physical mechanisms adjusted and calibrated in accordance with the performance data collected.

Contractor: Arno Keinonen Arctic Consulting Inc., Calgary, Alberta

Report: None to date

Schedule: November 1987 - December 1988
Funding: TDC $160 000
Project Number: 6966
File Number: D 1460-243
Project Officer: Ian M. Bayly

Effects of Corrosion on Arctic Structures

As commercial activities increase in the North, it is important to be able to predict the effects of corrosion on steel vessels and structures in an Arctic environment. Present knowledge in this area is quite limited.

In this project researchers are studying the effects of corrosion on the strength of Arctic vessels and structures. They plan to develop guidelines on corrosion management in the Arctic.

Data will be provided by the Gulf Canada Corporation and other companies operating marine structures and vessels in the Arctic. Researchers will use stress analysis techniques to assess the severity of the corrosion under various environmental conditions based on documented case histories. The contractor will make recommendations for design and operation of structures aimed at limiting or controlling corrosion.

Contractor: F.G. Bercha and Associates (Alberta) Ltd., Calgary, Alberta

Report: None to date

Corrosion on hull of the MV Kalvik *after extensive operations in the Beaufort Sea*

Schedule: December 1987 - November 1988

Funding:	Supply and Services Canada	$70 000
	TDC	$25 000
	CCG	$25 000
	EMR – Energy R&D Program	$20 000
		$140 000

Project Number: 6935
File Number: D 1460-252
Project Officer: Neil R. Gore

Ice Ridge Modelling

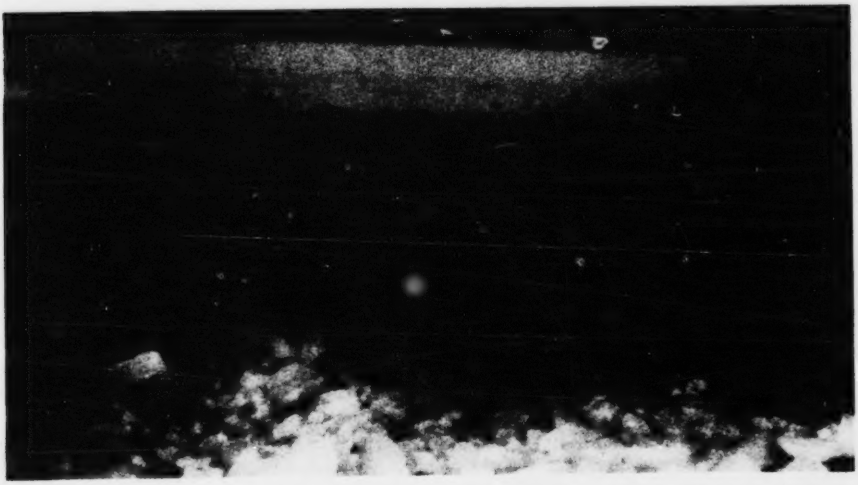
Ice basins and ship models are used to evaluate the power required by icebreaking vessels to transit level ice sheets of varying thicknesses and compositions. However, most ice fields in the Arctic are not level: they contain pressure ridges formed from rubble ice or from ice of previous years. Ships may encounter up to ten ridges per kilometre and must resort to ramming the ridges in order to penetrate them.

In this project researchers are trying to develop a practical way of modelling ice ridges in order to test the performance of icebreaking vessels in ridges.

The ridge modelling technique will be validated by comparing the performance of a selected icebreaker model in simulated ridges with the full-scale performance of the icebreaker during field trials.

Contractor: Arctec Newfoundland Ltd., St. John's, Newfoundland

Report: None to date



Ship model traversing the ice sheet and ridges in the tank

Schedule: February 1988 - September 1988

Funding:	TDC	$127 000
	National Research Council Canada	$30 000
		$157 000

Project Number: 7000
File Number: D 1460-257
Project Officer: Thomas Peirce

Scale Model Testing of R-Class Hullforms

The ability to accurately predict the performance of various icebreaker hull designs from model tests, particularly small-scale model tests, is an important economy in ship design. Canada's R-Class (River Class) icebreakers are among the best performers in the Canadian Coast Guard fleet. TDC is promoting a program of further research into the R-Class to demonstrate the effects of scale.

The objectives of this project were to develop icebreaking predictors based upon the whole R-Class scale effect program through the testing of a 1:8 scale model.

Results of the tests correlated well with full-scale tests only for tests in thin ice. Results of full-scale tests in thicker ice were affected by snow cover on the ice during the trials.

The findings of this work will also be used to investigate the effects of scale by comparing them with results of 1:20 and 1:40 scale model tests being conducted by the National Research Council's Institute for Marine Dynamics. These comparisons will reveal the effects of scale and will be used to refine the experimental techniques used in the Institute's model test tank.

Contractor: Arctec Newfoundland Ltd., St. John's, Newfoundland

Report: TP 8828E, The testing of the 1:8 scale model of the R-Class in level ice, Arctec Newfoundland Ltd., 1987

1:8 model of an R-Class hullform used in test program

Schedule: November 1986 - December 1987
Funding: TDC $73 000
CCG $25 000
$98 000
Project Number: 6802
File Number: D 1460-245
Project Officer: Jacques E. Laframboise

Star-Vue/Marine-Vue Integration Upgrade

TDC has been pursuing several research and development projects in support of an integrated ice analysis and navigation system featuring state-of-the-art electronic display systems for marine and airborne radar.

The integrated system includes:

- Star-Vue, which receives, stores, and interactively displays images representing ice condition data sent to the ship from aircraft carrying radar sensing equipment. This information is used by navigators to select the optimum path through ice.
- Marine-Vue, which displays real-time and processed radar images relayed from marine radar systems. This information is used to locate the position of the ship on the Star-Vue display.

A prototype integrated system was field tested aboard the cargo icebreaker MV *Arctic* during summer 1986. The tests identified several areas for improvement. Meanwhile, recent developments in digital processing hardware and techniques offer still more ways of improving the system's electronic displays.

In this project, researchers are upgrading the Star-Vue and Marine-Vue hardware and software to improve the display of the ship's radar. Features being added include: a differential synchro to allow a 'north up' display; a marine-type cursor for range, bearing, and azimuth for a number of operator-selected targets; display of additional ship's data; a radar video processor to improve presentation control; and, components for integrating a dual polarization radar antenna developed by the Department of Fisheries and Oceans. Upgrades, based on recommendations made by MV *Arctic* personnel, are also planned for the radar interconnections to the system.

Sea trials for the upgraded system are planned for the 1988 season.

Contractor: Intera Technologies Ltd., Calgary, Alberta

Report: None to date

Schedule: October 1987 - July 1988

Funding:	EMR – Energy R&D Program	$150 000
	TDC	$69 892
		$219 892

Project Number: 6960
File Number: D 1460-238-4
Project Officer: Maurice Audette

Star-Vue Interactive Assistance

Commercial shipping in the Arctic requires specialized navigational tools for avoiding ice hazards and for identifying appropriate tracks through ice fields. The Star-Vue system, using synthetic aperture radar (SAR) imagery for its display presentation to the navigator, is one example of a uniquely Canadian contribution to this specialized need. Deployment of Star-Vue to a number of Canadian Coast Guard vessels requires that a more 'user friendly' system be developed.

Recent developments in digital processing hardware and techniques have made a number of highly desirable features readily accessible to shipboard electronic display users. It is now possible to integrate a number of display-processing systems and analysis sub-systems and to provide interactive help in processing the information.

The objectives of this project are to acquire a knowledge base and to develop a prototype system that can interactively help a navigator interpret SAR imagery representing ice conditions in a ship's projected track.

The knowledge base is being built by defining, with the help of experts, SAR images that reflect different combinations of ice types, seasons, and geographical areas. Researchers are also developing a system that will present the user with probable interpretations for the Star-Vue display. This system will be implemented on an image analysis system able to operate in either the examining or learning modes depending on the experience of the user. It will be tested by experts in SAR representations of ice conditions.

Ultimately the prototype will consist of an image display system, interactive software, and an image data base stored on a random access disk. The prototype should provide a solid reference for the development of an on-line tactical navigating tool. It could also be the basis for a training aid.

Contractor: Intera Technologies Ltd., Calgary, Alberta

Report: None to date

Schedule: October 1987 - March 1989

Funding:	EMR – Energy R&D Program	$154 000
	TDC	$151 950
		$305 950

Project Number: 6944
File Number: D 1460-238-3
Project Officer: Maurice Audette

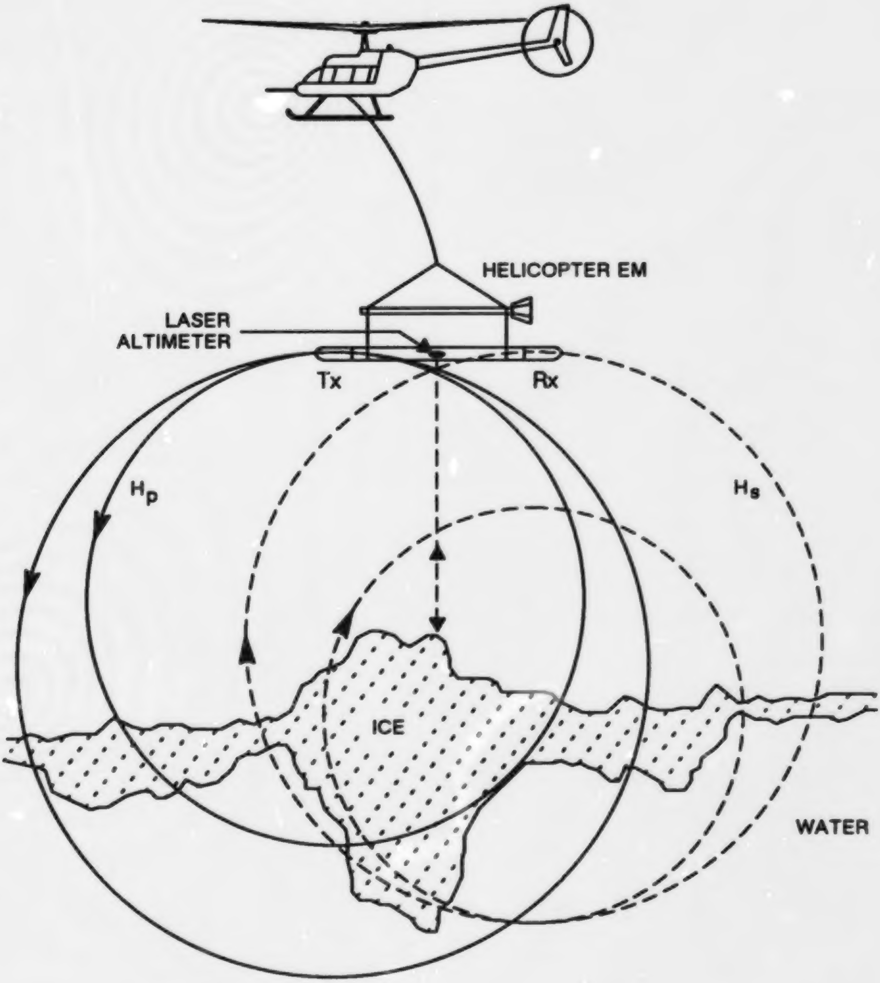

HELICOPTER EM
LASER ALTIMETER
Tx
Rx
H_p
H_s
ICE
WATER

Illustration of helicopter-borne electromagnetic sensing system. The transmit coil creates a primary magnetic field H_p that sets up eddy currents in a conductive medium such as ice. A secondary magnetic field H_s results, which is detected by the receive coil.

Evaluation of Ice Thickness Sensors

An all-weather, airborne instrument to measure the thickness of sea ice could help to extend the shipping season and to improve ship safety. Since 1980, TDC has supported MPB Technologies Inc. in the development and evaluation of a synthetic pulse radar for measuring the thickness of remote sea ice. Two other experimental measurement systems use different technologies: the Instrumar impulse radar system and the Geotech electromagnetic induction system.

The objective of this project is to evaluate and compare the three systems by testing them in the field. The results of this study will indicate the direction for future development work.

Researchers conducted initial shake-down trials in southern Canada to correct operational and logistical problems arising from the trial procedures. The actual field trials were conducted in the Arctic. The results of the trials indicated that radar provides an accurate measurement of ice thickness only when the ice is cold and homogenous. Accurate measurements could not be achieved in ice deformities such as ridges and melting ice. Electromagnetic sensors seem to be insensitive to variations in the characteristics of sea ice and may be better suited to Canadian shipping needs.

Researchers estimate the cost of developing an operational electromagnetic system will be $1 million over three years.

Contractor: Canpolar Inc, Toronto, Ontario

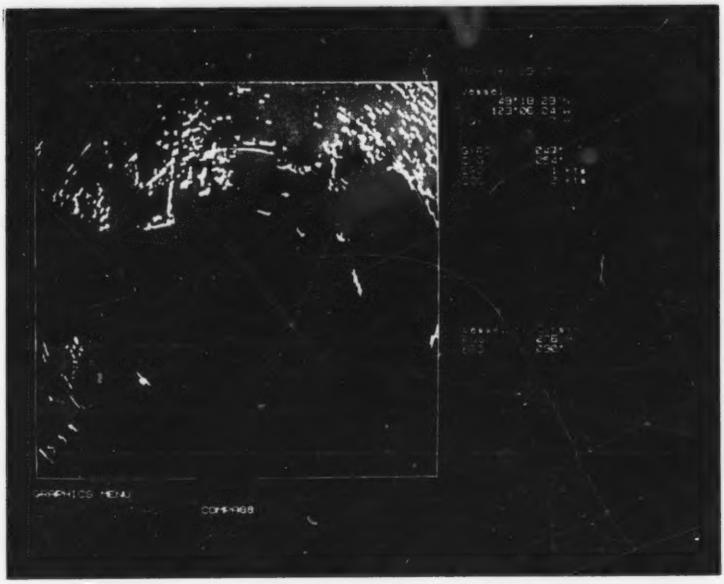
Report: TP 9169E, Evaluation of sea ice thickness sensors, Canpolar Inc., 1988

Schedule: March 1986 - June 1988

Funding:	**TDC**	**$177 000**
	Department of Fisheries and Oceans	**$40 000**
		$217 000

Project Number: 6606
File Number: D 1460-126-3
Project Officer: Maurice Audette

SINADS on bridge of CCGS **Nicolet**


Vessel
49°18.23
123°06.04
GRAPHICS MENU
COMPASS

SINADS display superimposes radar information onto stored imagery representing surrounding area.

Shipboard Integrated Marine Navigation System

There are a number of electronic navigation aids, including the recently introduced electronic charts, used onboard ships. These aids present mariners with an increasing amount of complex navigational information. The information is always useful and sometimes vital to the safe passage of the vessel. However, at present there is no system for gathering, integrating, and consistently displaying information from various sensors to make it more accessible to mariners for solving navigation problems.

TDC is supporting a project to develop a fully integrated navigation and display system, SINADS, for use on a ship's bridge.

The concept features digitized marine radar imagery superimposed on pre-stored digital electronic charts to provide graphic representation of a ship's location. The system accepts information from various navigation sensors aboard the ship, including short-wave microwave transponders, Loran C, global positioning systems, and collision avoidance radar. It will attempt to resolve possible scale and pattern mismatches among various displays representing such things as radar returns and prestored maps. SINADS will generate collision avoidance alarms and record the ship's track history for future analysis.

Successful development of SINADS could significantly improve navigation in confined waters benefiting a variety of users including the St. Lawrence Seaway and other narrow channel operators, coastal ferry operators, and the Canadian Coast Guard.

Researchers have developed a prototype system. It will be evaluated aboard the Canadian Coast Guard ship *Nicolet* during fall 1988.

Contractor: Offshore Systems Ltd., North Vancouver, British Columbia

Report: None to date

Schedule: November 1986 - November 1988

Funding:	Supply and Services Canada	$388 092
	EMR – Energy R&D Program	$200 000
	Canadian Coast Guard	$62 000
	Department of National Defence	$40 000
		$690 092

Project Number: 6740
File Number: D 1460-240
Project Officer: Howard Posluns

Ice Navigation Console Upgrade

Since 1983 TDC has been supporting the development of a shipboard ice navigation support system (SINSS) in collaboration with Canarctic Ltd of Ottawa. SINSS is a unique system developed for the challenging task of navigating through the ice fields found in Canadian Arctic waters. Most of the work so far has focussed on receiving high-quality, real-time ice and weather information onboard the vessel and developing effective display technologies.

The world's largest icebreaking bulk carrier, MV *Arctic*, has been used for most of the testing of SINSS components. The first-generation SINSS now resides aboard the vessel. It is capable of receiving and displaying satellite images as well as airborne and marine radar signals for use in ice navigation.

Many of these components are off-the-shelf items not designed for shipboard use. This has created problems in the deployment and integration of these components on the bridge. Cabling, for example, had to be routed for convenience rather than permanence.

In 1985 the bridge was expanded to increase the work area, but no major changes were undertaken nor was any special attention paid to ergonomic considerations or to the nature of the components and their interconnection. Canarctic, the ship's owner, is now undertaking a bridge design evaluation in anticipation of major modifications to the bridge infrastructure.

The objective of the current TDC project is to design a new-generation ice navigation console and associated wing consoles that will adequately support SINSS components. A preliminary design has been developed and reviewed. The final design, incorporating recommendations arising from the review, is being completed. The contractor will produce production design drawings and procurement and installation cost estimates for the upgraded SINSS ice navigation console.

The upgraded console will be installed before the 1988 navigation season.

Contractor: Canarctic Shipping Company Ltd., Ottawa, Ontario

Sub-contractor: Fleet Technology Ltd. (formerly Arctec Canada Ltd.), Kanata, Ontario

Report: None to date

Schedule: January 1988 - June 1988
Funding: TDC $47 200
Project Number: 7044
File Number: D 1460-240-2
Project Officer: Michael A. Stenson

Precision Radar Integrated Navigation System

For several years, TDC has been supporting projects aimed at improving the precision of marine navigation for Canada's inland waterways and coastal regions particularly in areas where the shoreline does not offer the good radar reflection needed for accurate positioning. Independent work carried out by McMaster University's Communications Research Laboratory and by Offshore Systems Ltd. has resulted in the development of a passive polarimetric retro-reflector and a shipboard precision integrated navigation system (PINS). However, there remains a clear need for a less costly, all-weather, vessel-positioning system for freighters, ferries, and other vessels operating on inland and coastal waterways.

The current project combines the innovative work of McMaster University and of Offshore Systems Ltd. with an existing radar-positioning technique, RADARFIX, to create an integrated, precision navigation display system, NAVFIX. Both PINS and RADARFIX have been evaluated operationally on various vessels as independent, stand-alone systems. The passive radar retro-reflectors have only been evaluated in static tests.

NAVFIX components are now being designed and constructed. These include: a dual-polarized antenna to interface with RADARFIX; trihedral radar reflectors; a method of integrating the polarimetric radar technology with PINS graphic display and navigation system; and, several software packages. A prototype NAVFIX system is scheduled to be installed aboard Marine Atlantic's MV *Atlantic Freighter* in summer 1988. Testing and evaluation will follow.

Contractor: Offshore Systems Ltd., North Vancouver, British Columbia

Sub-contractor: Communications Research Laboratory,
McMaster University, London, Ontario

Report: None to date

Schedule: April 1987 - June 1989

Funding:	**Supply and Services Canada**	**$330 000**
	TDC	**$196 284**
	Marine Atlantic	**$150 000**
	Offshore Systems Ltd.	**$96 000**
		$772 284

Project Number: 6877
File Number: D 1460-249
Project Officer: Maurice Audette

Selection of life rafts, with and without radar reflectors, used in the tests

Conventional ship's radar and high-performance collision avoidance radar were used for detection.

Detection of Small Objects at Sea

Canadian offshore activity is increasing. The growth in fishing fleets and petroleum exploration is adding to the proliferation of vessels and structures at sea. To enhance the safety of these operations, improved technology is needed to detect, identify, and monitor small objects such as boats, life rafts, and survival suits in an ocean environment. Such surveillance technology could save lives and reduce the cost of search and rescue operations. TDC has been tasked by the Canadian Coast Guard to assist in developing improved search and rescue technology.

TDC supported two projects aimed at investigating existing detection techniques and methods used by airborne and sea-surface vehicles. The projects concluded that although radar is the most effective technology for detecting small objects at sea, infra-red sensors are best for short-range night detection. Current research involves evaluating sophisticated radar systems through a ship-based search and rescue experiment.

In summer 1987 three radar systems were tested aboard the Canadian Coast Guard ship *Sir William Alexander*. The radars were: Sperry's conventional X-band ship's radar and collision avoidance radar, and Raytheon's Pathfinder ST radar. The tests were conducted in a variety of sea conditions using several different targets, including four- and six-person life rafts with and without radar reflectors.

Researchers are analyzing the data to produce probability curves for detecting several classes of objects using certain search procedures.

Contractors: NORDCO Ltd., St. John's, Newfoundland

Reports: None to date

Schedule: March 1987 - September 1988
Funding: CCG $250 000
TDC $112 310
$362 310
Project Number: 6846
File Number: D 1460-220-5
Project Officer: C. Alfred Versailles

Ice Loads on Fishing Vessels

As Newfoundland fishermen venture further afield in search of fish, they increase the risk of encountering floating ice. Existing standards for hull strength in fishing trawlers may be inadequate for the new demands placed on vessels. Careful review of the design criteria for small fishing vessels is needed.

This project gathered data to help assess the adequacy of trawler hull structure designs for operation in open pack ice off the coast of Newfoundland. The project was undertaken with the cooperation of National Sea Products of Dartmouth, Nova Scotia.

A system of measuring the impact of ice on a hull was installed on the National Sea Products trawler *Cape Brier* in 1984. Data was collected during voyages made in spring 1984 and, following minor modifications to the measuring system, in spring 1987.

Based on the limited data collected, TDC is considering the need for additional analytical tools and data acquisition activities.

Contractor: Fisheries Resource Development Ltd., Halifax, Nova Scotia

Reports: *(From previous work)*

TP 6046E, Measurement of ice forces on fishing vessels, Arctec Canada Ltd. and Fisheries Resource Development Ltd., 1984

TP 6045E, Measurement of ice forces on fishing vessels, summary report, Arctec Canada Ltd. and Fisheries Resource Development Ltd., 1984

Cape Brier *in Ice*

Schedule: December 1985 - June 1988
Funding: TDC $95 473
CCG $80 000
$175 473
Project Numbers: 6600, 6611
File Number: D 1460-210
Project Officer: Neil R. Gore

Wind and Wave Climate Atlas

Canadian ships built for the Great Lakes can, with some restrictions, operate in the Gulf of St. Lawrence and on the open ocean. Differences in wind and wave conditions in these marine environments must be taken into account in designing and operating vessels. Information about wind and wave climates is difficult to obtain, forcing designers and operators to apply the most stringent North Atlantic rules to ensure ship safety; some ships are prohibited from operating in East Coast, off-shore areas. More accessible, organized data on wind and wave climates would facilitate more rational design and operating criteria, which in turn could extend the operating zones for Canadian lakers.

The objective of this project is to summarize, in a usable format, existing wind and wave data for the Great Lakes, the Gulf of St. Lawrence, and the Canadian East Coast. Researchers will identify data sources, review the quality of the data, and develop a suitable presentation format.

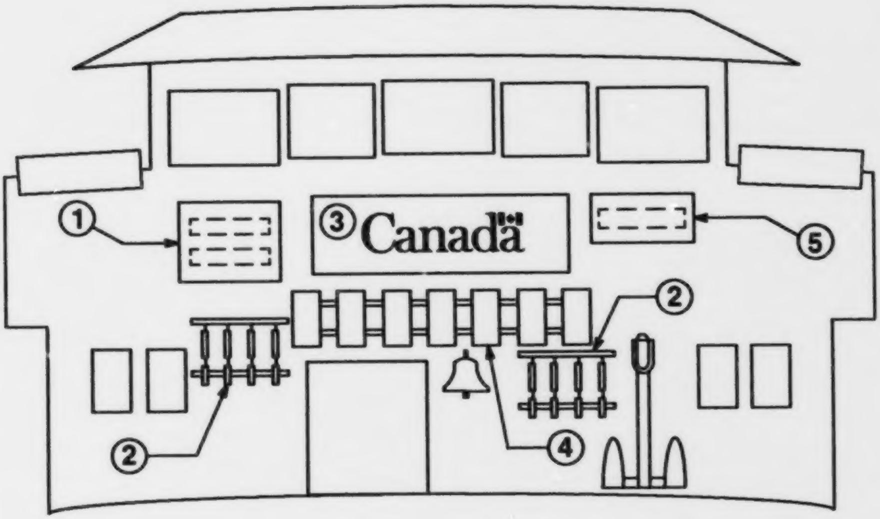
The researchers selected several sites in the Great Lakes, Gulf of St. Lawrence, and East Coast off-shore to serve as the basis for reference grids. A presentation format for the atlas is being developed.

Contractor: MacLaren Plansearch Ltd., Halifax, Nova Scotia

Report: None to date

Laker in heavy wave action on the Great Lakes

Schedule: December 1987 - March 1989
Funding: EMR - Energy R&D Program $122 000
Project Number: 6894
File Number: D 1460-140-3
Project Officer: Thomas Peirce



1. ELECTRICAL MAT HEATERS 1000 W/m^2
2. CYLINDERS COATED WITH ICE PHOBIC PAINTS
3. ELECTRICAL HEAT TRACING TAPES
4. STEEL PLATES COATED WITH ICE PHOBIC PAINTS
5. ELECTRICAL MAT HEATER 800 W/m^2

De-icing experiments on the trawler Cape Roger

Ship De-icing Tests

Fishing vessels and supply ships operating off the East Coast of Canada sometimes become heavily coated with ice. Under certain conditions, ship icing can be hazardous: life-saving equipment can become unusable; the deck can become too slippery for the crew to work on; and, in extreme cases, the ship can capsize.

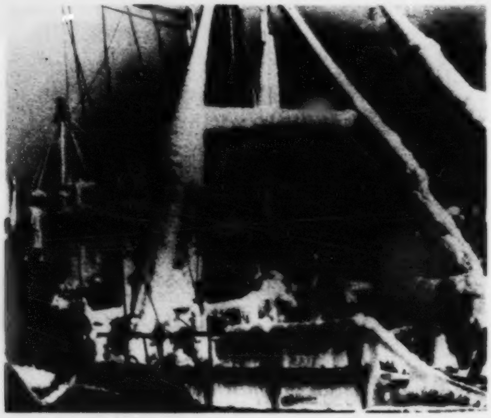
Several methods are currently used to prevent icing and to remove accumulated ice. In this project researchers are investigating the effectiveness and cost of each of these methods. The final report will recommend the best way of using each method.

Four de-icing methods are being tested: ice phobic paints, heat tracing tape, inflatable panels, and an air gun. The methods are being tested over two winter seasons on two ships: the *Cape Roger*, a patrol vessel operated by the Department of Fisheries and Oceans, and the *Sanderling*, operated by Atlantic Sea Route Ltd.

During the first season, the researchers conducted laboratory tests on the ice phobic paints and designed the inflatable de-icers. Ship trials were arranged to test the ice-phobic paints, heat tracing tape, and air guns. However, little data was collected because of mild weather. The researchers evaluated the test procedures and refined the tests scheduled for winter 1988-89.

Contractors: Melville Shipping Ltd., Ottawa, Ontario

Reports: None to date

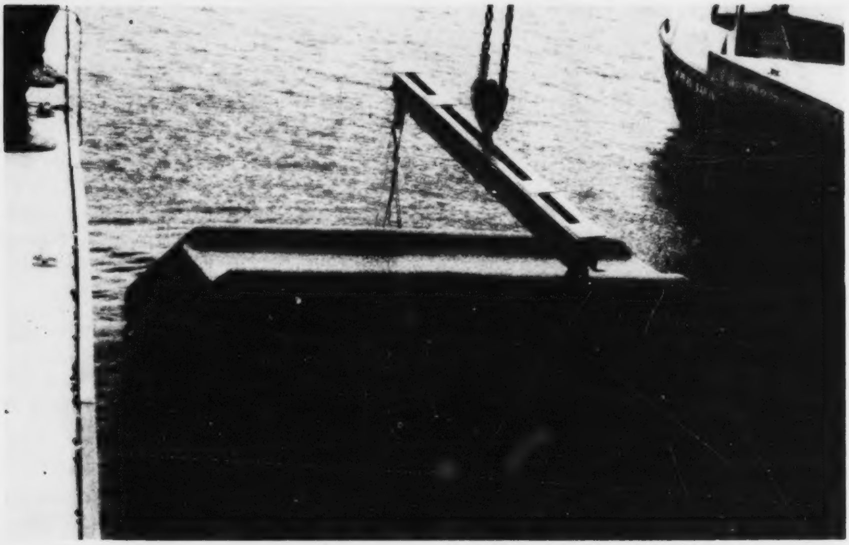


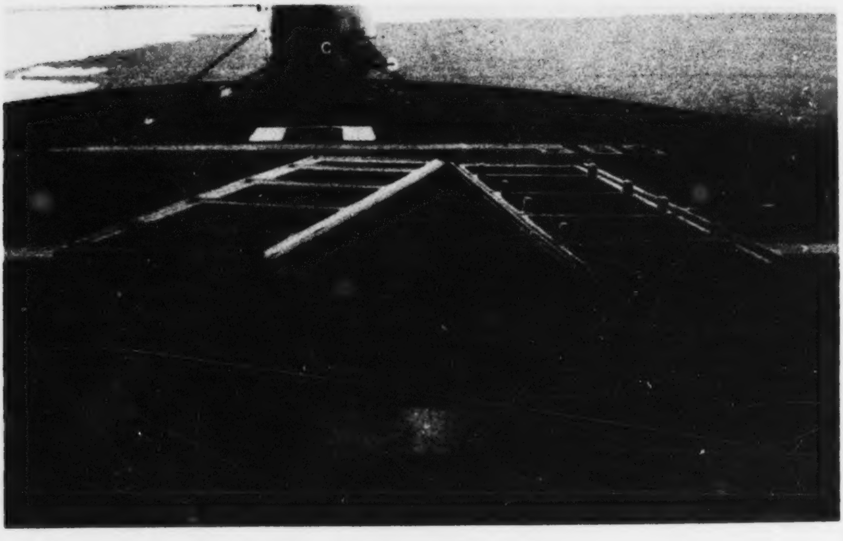
Fishing trawler covered in ice

Schedule: January 1988 - August 1989

Funding:	EMR – Energy R&D Program	$68 610
	TDC	$27 823
	Supply and Services Canada	$18 000
		$114 433

Project Number: 7024
File Number: D 1460-258
Project Officer: Pierre L. Semery





Prototype Arctic survival sled under test

Arctic Survival Sled

Conventional marine life-saving equipment and emergency procedures are generally not adequate for the Arctic environment. If a ship has to be abandoned in Arctic waters, conventional equipment cannot be easily transported across water and ice to a safe location.

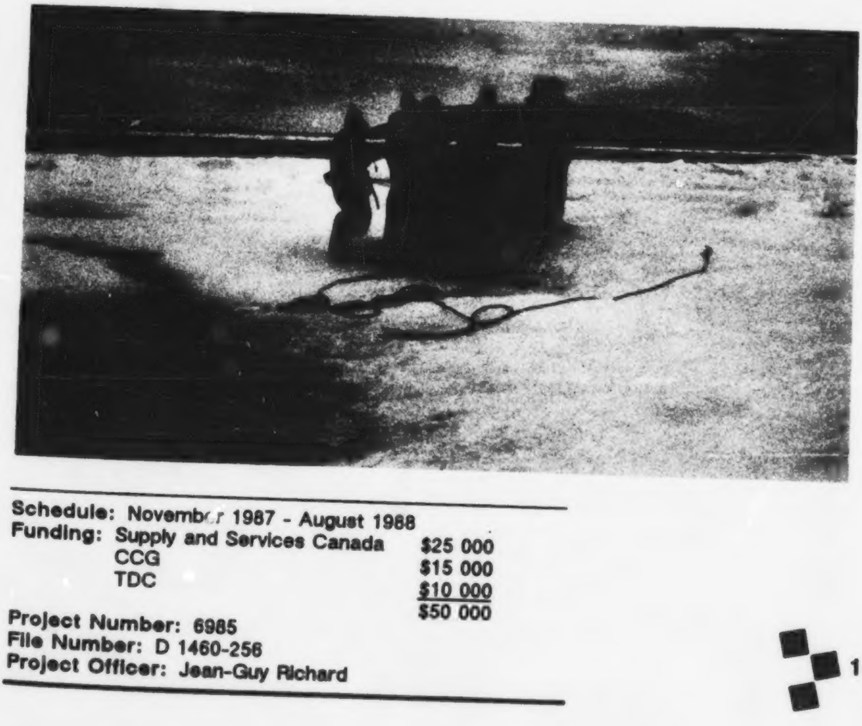
The objective of this project is to design, construct, and test a floating sled capable of transporting survival equipment for ten people across water and ice. The sled would contribute to the Canadian Coast Guard's efforts to improve the safety and efficiency of Arctic marine operations.

Design specifications called for the sled to be capable of carrying a load of 100 kg, to be at least two metres long to enable transport of an injured person, and to be constructed of materials capable of withstanding temperatures of -40°C and launching from a ship's deck to the water.

A prototype sled was completed in April 1988 and tests were conducted during the early summer. The results of these tests successfully demonstrated the feasibility of the design.

Contractor: Melville Shipping Ltd., Ottawa, Ontario

Report: None to date



Schedule: November 1987 - August 1988

Funding:	Supply and Services Canada	$25 000
	CCG	$15 000
	TDC	$10 000
		$50 000

Project Number: 6985
File Number: D 1460-256
Project Officer: Jean-Guy Richard

Ship Manoeuvring Standards

The International Maritime Organization (IMO) has drafted a resolution calling for standards for manoeuvring ships. The standards would regulate the operation of existing vessels and the design of new ships. Canada, as a member of the IMO, supports this undertaking. Studies by the Canadian Coast Guard have shown that the manoeuvring performance of Canada's fleet varies widely. Some ships do not operate within international norms and some are below international averages for turning circle and stopping distance. However, clear conclusions cannot be drawn from these studies because there is no systematic method for collecting and reporting ship manoeuvring performance.

To resolve the problem, TDC is supporting a project to develop a standard method for determining the manoeuvring performance of the Canadian fleet. Canada will present the method at the next IMO conference.

Researchers are assessing the manoeuvring characteristics of a laker (loaded and in ballast) and a passenger ferry by analyzing the basic hull geometry of the ships. Sea trials of the ships will be conducted using a standard test program. Manoeuvring tests will include turning circles, zigzags, spiral manoeuvres, and crash stops.

Contractor: German and Milne Inc., Ottawa, Ontario

Report: None to date

Ships operating in confined waters must meet stringent manoeuvring standards. (Photo courtesy of Canada Steamship Lines).

Schedule: February 1988 - July 1988

Funding:	TDC	$69 000
	Supply and Services Canada	$69 000
		$138 000

Project Number: 7051
File Number: D 1460-259
Project Officer: Michael Stenson

Data Logging and Performance Evaluation of Tug/Barge Systems

Tug and barge transportation is widely used by forestry and other resource-based industries in British Columbia. Improvements in tug/barge systems could yield better fuel-efficiency and operational performance. To make improvements, designers and operators need a broad base of full-scale performance data on existing tug/barge systems.

In this project, researchers are evaluating the efficiency of all substantial elements of tug/barge systems by measuring performance parameters at full scale during normal operations.

The researchers have modified and calibrated a portable data logging system for installation on operating tug/barge systems. The system measures resistances of the tug, towline, and barge; directional stability; and, other hydrodynamic performance elements. The researchers will use the data to define the energy effectiveness of principal components of each tug/barge system. They will also evaluate the effects of degrees of performance change on the economies of tug/barge operation.

Data have been collected on three tugs and barges. However, problems with the instrumentation and the subsequent need to re-schedule testing are causing delays in the project. Completion of the data collection and analysis is now planned for fall 1988.

Contractor: Seatronics Technologies Ltd., Burnaby, British Columbia

Report: *(Draft)* Development of energy-effective conceptual towed tug/barge systems, Seatronics Technologies Ltd., 1987

Energy-efficient tug model

Schedule: August 1986 - December 1988

Funding:	EMR – Energy R&D Program	$100 000
	TDC	$93 900
		$193 000

Project Number: 6673
File Number: D 1460-180-4
Project Officer: Ian M. Bayly

Barge Directional Stability

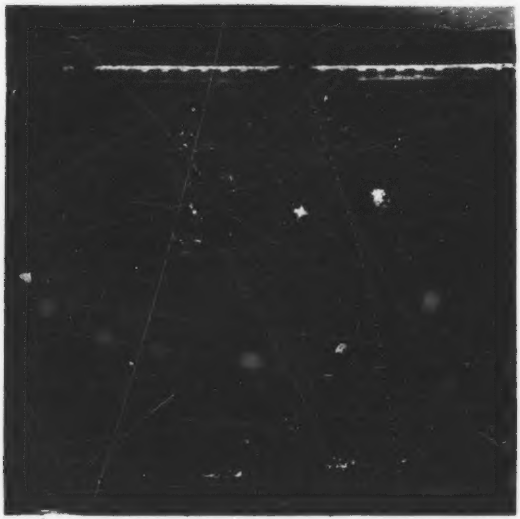
Barges are an economical way of moving cargo. They are even more efficient when pushed rather than towed, because a tug pushing a barge moves as a single ship and therefore has less drag than a tug towing a barge. However, in order to push a barge in certain sea and navigating conditions, the barge must be equipped with an expensive, patented connecting device. Operators estimate that a normally pushed barge must be towed approximately 20 percent of the time.

The objective of this project is to test and evaluate various stern configurations for barges that might promote directional stability and reduce drag while a normally pushed barge is being towed.

Researchers are using a 1:15 scale barge model in open water. The stern of the model can be fitted with stern sections to which different directional devices are attached. Researchers will measure the drag created by the devices in both modes versus directional stability in the towed mode.

Contractor: Robert Allan Ltd., Vancouver, British Columbia

Report: *(Draft)* The effects of various stern configurations on the directional stability of towed barges, Robert Allan Ltd., 1988



Notched stern of a 1:15 scale barge model used to test directional devices

Schedule: November 1986 - July 1988
Funding: TDC $90 900
Project Number: 6864
File Number: D 1460-237
Project Officer: Jacques E. Laframboise

Fibre-Optic Standards for Marine Installations

Fibre-optic technology has a promising future in ships. Fibre-optic cables transmit a wider bandwidth than wire cables and are less vulnerable to electrical interference. They offer the possibility of engine room automation and remote control in an electrically noisy and physically harsh environment.

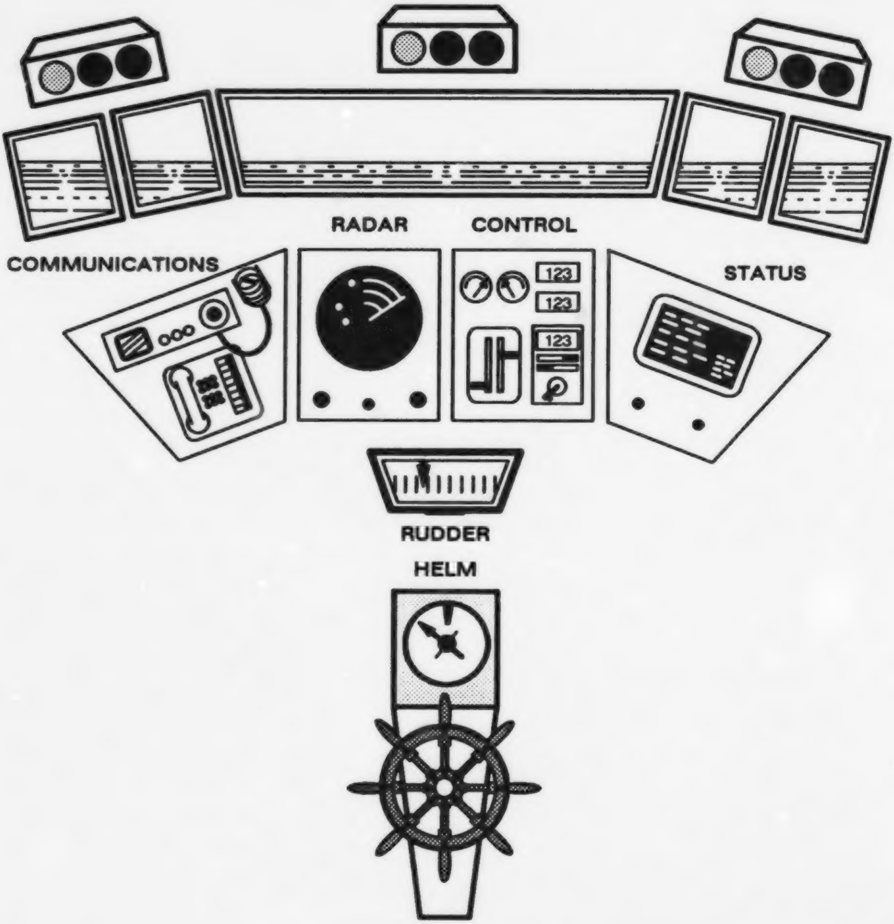
TDC has developed preliminary standards for the use of fibre optics aboard civilian marine vessels. These standards are based on the result of field tests conducted aboard the Canadian Coast Guard ship *Louis S. St. Laurent* while on icebreaking duties in 1987.

The objective of this project is to foster international adoption of fibre-optic standards. The contractor is monitoring the activity of relevant standard-writing organizations and consulting the shipbuilding industry and such interested organizations as the Canadian Coast Guard. The draft standards will be presented to the U.S.-based Society of Naval Architects and Marine Engineers and to the International Electro-mechanical Commission in 1989.

Contractor: Focal Technologies Inc., Dartmouth, Nova Scotia

Report: *(From previous work)* TP 8469E, Development and testing of a fibre optic data system for marine transportation, Focal Technologies Inc., 1987

Schedule: August 1987 - February 1989
Funding: TDC $35 576
Project Number: 6932
File Number: D 1460-198-3
Project Officer: Micha Avni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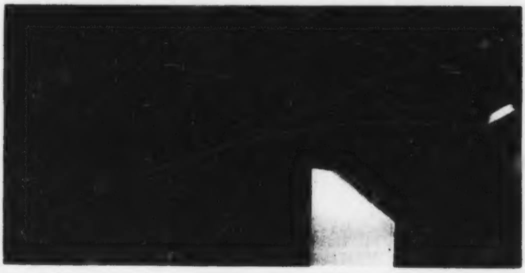
Schematic of bridge and equipment layout for CABINS

Tests of CABINS conducted by the Canadian Coast Guard evaluated fidelity of navigation bridge instruments, visuals, radar image, and area displayed.



Ice-Transiting Ship Bridge Simulator

An Arctic marine simulator would be a valuable tool in helping to establish safe and efficient year-round navigation in Canadian waters. It would assist designers in projecting the operational needs of a ship and could be used for training crew. TDC and the Canadian Coast Guard (CCG) have already conducted considerable research in the field. A data base has been developed which describes how a ship turns and moves in ice. Ergonomic research has explored functional characteristics, fidelity, visual imagery, and task analysis.

The objective of this project is to develop and validate a mathematical model for ship-turning performance in level ice, using the existing data base. The model will be applied to the bridge navigation simulator, CABINS, developed by Fleet Technology Ltd. of Kanata, Ontario.

Researchers developed and implemented the ice force algorithm on CABINS. Initial validation tests showed that the model must be improved for very low advance speeds and reverse manoeuvring.

Two Canadian Coast Guard captains conducted a complete operational evaluation of the improved model on CABINS. They concluded that CABINS is useful as a full bridge navigation simulator and the turning model is satisfactory as a preliminary model for ship handling in ice.

Contractor: Fleet Technology Ltd. (formerly Arctec Canada Ltd.), Kanata, Ontario

Report: *(Draft)* Development of a Canadian Arctic bridge navigation simulator, Fleet Technology Ltd., 1988

Schedule: July 1987 - April 1988

Funding: TDC	$45 824
Supply and Services Canada	$40 000
	$85 824

Project Number: 6904
File Number: D 1460-250
Project Officer: Jean-Guy Richard

Air Cushion Vehicle Operations in the Port of Chicoutimi

The Port of Chicoutimi in Quebec would like to provide year-round access for shipping at the petroleum terminal at Pointe-à-l'Islet. However, the channel leading to the terminal is too narrow for conventional icebreakers. Also the task of breaking the ice in port areas is considered to be a local responsibility. TDC has been working with the Port of Chicoutimi to develop air cushion technology that could permit carrying out this task cost effectively. The project evaluated the effectiveness of using a lightweight air cushion vehicle, the *Air Trek 140*, in breaking channel ice. The combination of icebreaking and tidal flow present at Chicoutimi would then move the ice downstream to a point where it could be handled by Canadian Coast Guard icebreakers.

The *Air Trek 140* was able to break ice up to 60 cm thick during the latter part of March 1987. This was weak, end-of-season ice. The vehicle could not be expected to break cold, fresh-water ice of the same thickness. Researchers considered using the vehicle to cut grooves in the ice to make it easier to break. A knife was constructed and fitted to the vehicle, but only one trial was conducted and the results were inconclusive.

Use of the *Air Trek 140* permitted the petroleum terminal to open 21 days earlier than its normal opening date, April 15. The researchers predict that if the vehicle began operating from the beginning of December and was properly maintained, the channel could be kept open year round. Continuous operations would prevent ice from becoming too thick.

Contractor: Ice Control Enterprises Inc., Hamilton, Ontario

Report: TP 8432E, Project "Frigonav" hovertype 140 operating experience February – March 1987, Ice Control Enterprises Inc., 1987

View of Air Trek 140 *in operation*

Schedule: January 1987 - December 1987

Funding:	TDC	$35 000
	Ports Canada	$12 000
		$47 000

Project Number: 6864
File Number: D 1460-247
Project Officer: Jacques E. Laframboise

REPORT
LISTING

Report Listing

This is a list of TDC reports published since the previous edition of the project directory. These reports are available free-of-charge from TDC while supplies last.

An annual list of the Centre's reports is given in "TDC Publications" (TP 2602) available on request from TDC.

Reports may also be borrowed through interlibrary loan from the Judith Nogrady Library at TDC in Montreal or from the Transport Canada Library and Information Centre, Transport Canada Building, 2nd floor, Ottawa, Ontario K1A 0N5.

Paper copies and microfiches of out-of-print reports are also available at various charges from Micromedia Ltd., 165 Hotel de Ville, Hull, Quebec J8X 3X2; telephone: 1 (800) 567-9669 (Maritimes, Ontario, Quebec), 1 (800) 569-1914 (Western provinces); fax: (819) 770-9265.

RAIL

Analyse du comportement thermique des wagons-citernes, volume 1 : Sommaire, J.E.S. Venart et al., University of New Brunswick, Fire Science Centre, 1985. TP 5809F

Augmented rail freight transportation research and development program - final report, March 31, 1986, Transportation Development Centre, 1986. TP 3756E

Background paper outlining the rationale and strategic needs for rail freight development in Canada, M.L. Driscoll, C. Schwier and R.M. Renfrew, Queen's University, Canadian Institute of Guided Ground Transport, 1986. TP 7295E

Bibliographie de l'électrification du rail/*Rail electrification bibliography*, L.C. Tait, K. Hamer et/and R.A. Grassby, Société d'études et de consultation du Canadien Pacifique Ltée/Canadian Pacific Consulting Services Ltd., 1986. TP 8408

Bombardier single-cylinder medium-speed research engine and test facility - phase III : qualification, M.L. Payne, Bombardier Inc., 1987. TP 8395E

Canadian railway motive power options and development priorities, G.W. English, C. Schwier, J.C. Michaud et al., Queen's University, Canadian Institute of Guided Ground Transport, 1987. TP 8819E

Catenary deflection under wind and ice loading, L.C. Tait, P.A. Irwin, S.L. Gamble, Canadian Pacific Consulting Services Ltd., 1986. TP 8046E

CP Rail grinding - field manual, S.T. Lamson and M.D. Roney, Queen's University, Canadian Institute of Guided Ground Transport, 1986. TP 8174E

Électrification du branchement Tumbler Ridge, H. Lockhart, B.C. Rail, 1986. TP 8334F

Engineering tests on BRE-Leyland railbus, W.J. Watson, National Research Council of Canada, 1986. TP 7914E

Explosion suppression system for rail tank cars and other containers holding pressurized liquids - mechanical design study, A.M. Birk, C. Critch, D.E.J. Lamb et al., Davis Engineering Limited, 1986. TP 7986E

Further development and testing of an end-of-train monitoring system, R.S. Heenan and Dr. R.J. Pomeroy, Glenayre Electronics Ltd., 1986. TP 7940E

Logiciel de simulation des opérations ferroviaires au Port de Montréal - analyse des scénarios, GIRO Inc., 1986. TP 8340F

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LRC wheel/rail interaction and suspension study program, David D. Taylor, Bombardier Inc., 1986. TP 8034E

Un moteur expérimental Ringbom-Stirling, rapport sommaire, Dr. G. Walker et Dr. O.R. Fauvel, University of Calgary, 1986. TP 7361F

Phase I interim report on the design and development of the Canadian advanced railbus, Dr. J.H. Stannard and P.E. Timan, All Transportation Technology Limited, 1986. TP 7809E

Portable train-based wheelchair lift design, U. Rutenberg and D. Mietzker, Rutenberg Design Inc., 1987. TP 8290E

Proceedings of the seminar on rail freight research & development, R. Maughan (editor), Maughan Railway Consulting Services Inc., 1986. TP 7946E

Radial axle truck tests - volume 3, 1985, V. Khatchadourian, R. Gonsalves and W. Pak, Canadian Pacific Ltd., 1986. TP 7982E

Railbus development and demonstration program, Sesto C. Vespa, Transportation Development Centre, 1987. TP 8668E

Rail electrification bibliography/*Bibliographie de l'électrification du rail*, L.C. Tait, K. Hamer and/et R.A. Grassby, Canadian Pacific Consulting Services Ltd./Société d'études et de consultation du Canadien Pacifique, 1986. TP 8408

Railway linehaul energy intensity: intermodal train resistance testing, G.W. English, J.D. Young, M. Devlin et al., Queen's University, Canadian Institute of Guided Ground Transport, 1987. TP 8225E

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Tank-car internal shell explosion suppression system: preliminary thermal feasibility study, R.G. Wilkinson and A.M. Birk, W.R. Davis Engineering Ltd., 1987. TP 8781E

Tank thermal response analysis - phase II: a study of the transient phenomena in a heated vessel during depressurization, Qi Wang and J.E.S. Venart, University of New Brunswick, Fire Science Centre, 1987. TP 8422E

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Track system model, S.T. Lamson, G.D. Thompson and A.B. Hazell, Queen's University, Canadian Institute of Guided Ground Transport, 1988. TP 9179E

Track/train dynamics - volume 6, 1985, Canadian Pacific Ltd., 1986. TP 7527E

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Train control system: test bed development system, G. Taylor and D.J. Klitch, BC Rail, and W.R. Tracey, Systek Engineering, 1987. TP 8154E

Tumbler Ridge branch line electrification demonstration, H. Lockhart, B.C. Rail, 1986. TP 8334E

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Wear and contact fatigue model for railway rail, Dr. J. Kalousek, National Research Council of Canada, 1986. TP 8344E

Wheel defect statistical analysis: Canadian coal trains, T. Moore and M. Devlin, Queen's University, Canadian Institute of Guided Ground Transport, 1986. TP 7915E

Winter testing and passenger demonstration of WCSS railbus, Dr. J.H. Stannard and H.R. Skoblenick, All Transportation Technology Ltd., 1986. TP 8160E

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Aluminum-air (salt water) battery for vehicles, David S. Strong, Alcan International Ltd., 1987. TP 8307E

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Canadian strategic highway research program: progress report 1987/88, John R. Pearson, Roads and Transportation Association of Canada, 1988. TP 9220E

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Conférence internationale sur la technologie du coussin d'air – compte rendu, septembre 1987/*Proceedings – 1987 CACTS international conference on air cushion technology, September 1987*, Société canadienne pour la technologie du coussin d'air/Canadian Air Cushion Technology Society, 1988. TP 8979

Computerized scheduling and brokerage demonstrations, Edmonton and Vancouver: a comparative analysis, Tom Geehan, TransVision Consultants Ltd., 1987. TP 8712E

Control of shift disturbances in the 64-ratio Ker-Train transmission, J.R.G. Morrison and R.J. Ferguson, Royal Military College of Canada, 1986. TP 7965E

Development of a costing method for trucking activities/*Développement d'une méthode de prix de revient des activités de camionnage*, summary report/rapport sommaire, Rémi Planche, Robert Dufresne, Samir Sayad et al., CGI Information Systems and Management Consultants Inc./Conseillers en gestion et informatique CGI Inc., 1986. TP 8023

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Économies d'énergie en utilisant des huiles synthétiques dans le moteur, transmission et les deux essieux arrière d'un véhicule routier, D.A. Ljubic, Institut canadien de recherches en génie forestier, 1986. TP 8140F

Energy economy through the use of synthetic oils in the engine, transmission and two rear axles of a road transport vehicle, D.A. Ljubic, Forest Engineering Research Institute of Canada, 1986. TP 8140E

Étude de faisabilité d'un système de gestion de circulation pour les corridors autoroutiers A-25/ Métropolitain/Décarie/Ville-Marie et Bonaventure/Pont Champlain, SNC/DeLuC Co-entreprise, 1988. TP 8955F

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Evaluation of public transit automated telephone information systems, David R. Ross and Richard M. Soberman, University of Toronto/York University, 1987. TP 8234E

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Feasibility of an accessible longer intercity bus, Pierre Asselin and Ed Sloot, Beauchemin-Beaton-Lapointe Inc., 1986. TP 8233E

Integrated transportation information system, G.W. Bachmayer, D. King and J.D. Spaeth, Oracle Communications Inc., 1987. TP 8293E

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